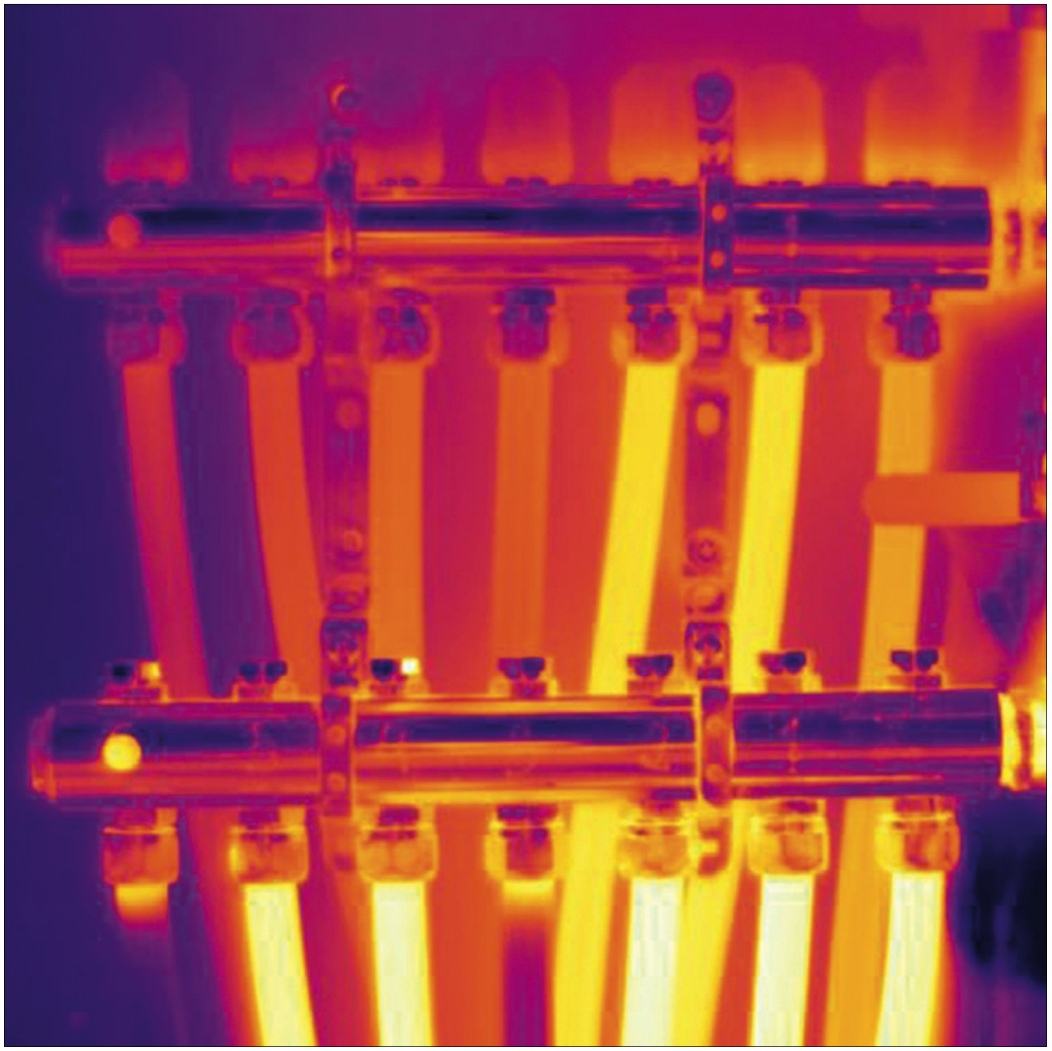
User's manual
Flir Tools/Tools+

4.0



User's manual
Flir Tools/Tools+

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1 Legal disclaimer

1.1 Legal disclaimer

All products manufactured by Flir Systems are warranted against defective materials and workmanship for a period of one (1) year from the delivery date of the original purchase, provided such products have been under normal storage, use and service, and in accordance with Flir Systems instruction.

Products which are not manufactured by Flir Systems but included in systems delivered by Flir Systems to the original purchaser, carry the warranty, if any, of the particular supplier only. Flir Systems has no responsibility whatsoever for such products.

The warranty extends only to the original purchaser and is not transferable. It is not applicable to any product which has been subjected to misuse, neglect, accident or abnormal conditions of operation. Expendable parts are excluded from the warranty.

In the case of a defect in a product covered by this warranty the product must not be further used in order to prevent additional damage. The purchaser shall promptly report any defect to Flir Systems or this warranty will not apply.

Flir Systems will, at its option, repair or replace any such defective product free of charge if, upon inspection, it proves to be defective in material or workmanship and provided that it is returned to Flir Systems within the said one-year period.

Flir Systems has no other obligation or liability for defects than those set forth above.

No other warranty is expressed or implied. Flir Systems specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

Flir Systems shall not be liable for any direct, indirect, special, incidental or consequential loss or damage, whether based on contract, tort or any other legal theory.

This warranty shall be governed by Swedish law.

Any dispute, controversy or claim arising out of or in connection with this warranty, shall be finally settled by arbitration in accordance with the Rules of the Arbitration Institute of the Stockholm Chamber of Commerce. The place of arbitration shall be Stockholm. The language to be used in the arbitral proceedings shall be English.

1.2 Usage statistics

Flir Systems reserves the right to gather anonymous usage statistics to help maintain and improve the quality of our software and services.

1.3 Changes to registry

The registry entry HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\Lsa \LmCompatibilityLevel will be automatically changed to level 2 if the Flir Camera Monitor service detects a Flir camera connected to the computer with a USB cable. The modification will only be executed if the camera device implements a remote network service that supports network logons.

1.4 Copyright

© 2013, FLIR Systems, Inc. All rights reserved worldwide. No parts of the software including source code may be reproduced, transmitted, transcribed or translated into any language or computer language in any form or by any means, electronic, magnetic, optical, manual or otherwise, without the prior written permission of FLIR Systems.

The documentation must not, in whole or part, be copied, photocopied, reproduced, translated or transmitted to any electronic medium or machine readable form without prior consent, in writing, from FLIR Systems.

Names and marks appearing on the products herein are either registered trademarks or trademarks of FLIR Systems and/or its subsidiaries. All other trademarks, trade names or company names referenced herein are used for identification only and are the property of their respective owners.

1.5 Quality assurance

The Quality Management System under which these products are developed and manufactured has been certified in accordance with the ISO 9001 standard.

FLIR Systems is committed to a policy of continuous development; therefore we reserve the right to make changes and improvements on any of the products without prior notice.

2 Notice to user

2.1 User-to-user forums

Exchange ideas, problems, and infrared solutions with fellow thermographers around the world in our user-to-user forums. To go to the forums, visit:

http://www.infraredtraining.com/community/boards/

2.2 Training

To read about infrared training, visit:

- http://www.infraredtraining.com
- http://www.irtraining.com
- http://www.irtraining.eu

2.3 Documentation updates

Our manuals are updated several times per year, and we also issue product-critical notifications of changes on a regular basis.

To access the latest manuals and notifications, go to the Download tab at:

http://support.flir.com

It only takes a few minutes to register online. In the download area you will also find the latest releases of manuals for our other products, as well as manuals for our historical and obsolete products.

2.4 Software updates

Flir Systems regularly issues software updates and you can update the software using this update service. Depending on your software, this update service is located at one or both of the following locations:

- *Start* > *Flir Systems* > *[Software]* > *Check for updates*.
- *Help* > *Check for updates*.

2.5 Important note about this manual

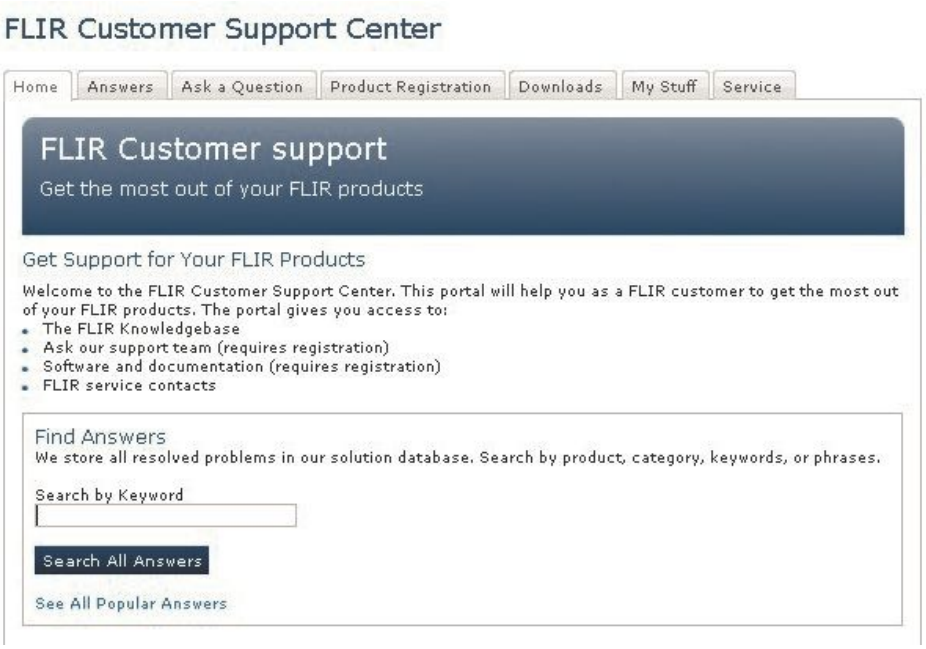
Flir Systems issues generic manuals that cover several software variants within a software suite.

This means that this manual may contain descriptions and explanations that do not apply to your software variant.

2.6 Additional license information

For each purchased software license, the software may be installed, activated, and used on two devices, e.g., one laptop computer for on-site data acquisition, and one desktop computer for analysis in the office.

3 Customer help


FLIR Customer Support Center
Home
Answers
Ask a Question
Product Registration
Downloads
My Stuff
Service
FLIR Customer support
Get the most out of your FLIR products
Get Support for Your FLIR Products
Welcome to the FLIR Customer Support Center. This portal will help you as a FLIR customer to get the most out of your FLIR products. The portal gives you access to:
The FLIR Knowledgebase
Ask our support team (requires registration)
Software and documentation (requires registration)
FLIR service contacts
Find Answers
We store all resolved problems in our solution database. Search by product, category, keywords, or phrases.
Search by Keyword
Search All Answers
See All Popular Answers

3.1 General

For customer help, visit:

http://support.flir.com

3.2 Submitting a question

To submit a question to the customer help team, you must be a registered user. It only takes a few minutes to register online. If you only want to search the knowledgebase for existing questions and answers, you do not need to be a registered user.

When you want to submit a question, make sure that you have the following information to hand:

- The camera model
- The camera serial number
- The communication protocol, or method, between the camera and your device (for example, HDMI, Ethernet, USB, or FireWire)
- Device type (PC/Mac/iPhone/iPad/Android device, etc.)
- Version of any programs from Flir Systems
- Full name, publication number, and revision number of the manual

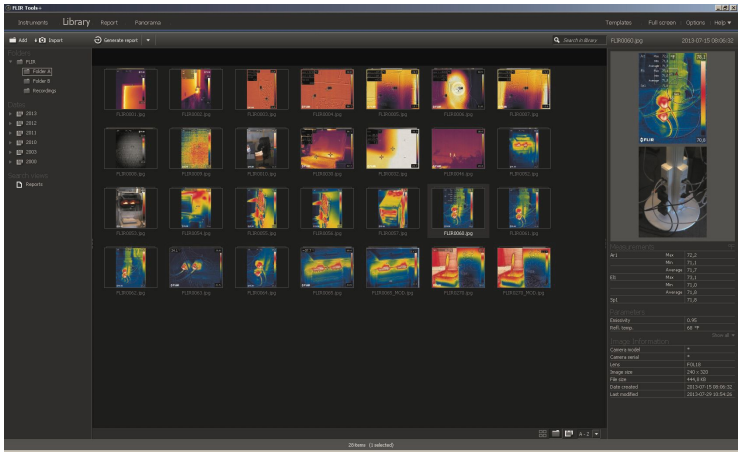
3.3 Downloads

On the customer help site you can also download the following:

- Firmware updates for your infrared camera.
- Program updates for your PC/Mac software.
- Freeware and evaluation versions of PC/Mac software.
- User documentation for current, obsolete, and historical products.
- Mechanical drawings (in *.dxf and *.pdf format).
- Cad data models (in *.stp format).
- Application stories.
- Technical datasheets.
- Product catalogs.

4 What is Flir Tools/Tools+?

4.1 Introduction



Flir Tools/Tools+ is a software suite specifically designed to provide an easy way to update your camera and create inspection reports.

Examples of what you can do in Flir Tools/Tools+ include the following:

- Import images from your camera to your computer.
- Apply filters when searching for images.
- Lay out, move, and resize measurement tools on any infrared image.
- Group and ungroup files.
- Create panoramas by stitching several smaller images into a larger one.
- Create PDF imagesheets of any images of your choice.
- Add headers, footers, and logos to imagesheets.
- Create PDF/Microsoft Word reports for images of your choice.
- Add headers, footers, and logos to reports.
- Update your camera with the latest firmware.

4.2 Comparison between Flir Tools and Flir Tools+

This table explains the difference between Flir Tools and Flir Tools+.

Feature/function	Flir Tools	Flir Tools+
Import images using USB.	X	X
Create IR/photo image groups manually.		X
Measure temperatures using spots, areas, lines, and isotherms.	X	X
Measure a temperature difference.	X	X
Adjust object parameters.	X	X
View a live image.	X	X
Save infrared *.jpg files from a live image.	X	X
Record a video sequence (*.seq).		X
Replay a recorded sequence.		X
Export a recorded sequence to *.avi.		X
Create a temporal plot.	X (live image only)	X (live image or recorded sequence)
Export plot data to Excel.	X	X
Export an image to *.csv format.	X	X
Create a panorama image.		X
Create a PDF report.	X	X

Feature/function	Flir Tools	Flir Tools+
Create a Microsoft Word report		X
Create text annotation templates for the camera.	X	X
Add/edit text annotations and image descriptions.	X	X
Listen to voice comments on infrared images.	X	X

5 Installation

5.1 System requirements

5.1.1 Operating system

Flir Tools/Tools+ supports USB 2.0 communication for the following PC operating systems:

- Microsoft Windows XP, 32 bit, SP3.
- Microsoft Windows Vista, 32 bit, SP1.
- Microsoft Windows 7, 32 bit.
- Microsoft Windows 7, 64 bit.
- Microsoft Windows 8, 32 bit.
- Microsoft Windows 8, 64 bit.

5.1.2 Hardware

Microsoft Windows XP:

- Personal computer with an Intel 800 MHz Pentium processor, or an AMD Opteron, AMD Athlon 64, or AMD Athlon XP processor.
- 1 GB of RAM.
- 20 GB of available hard disk space.
- CD-ROM or DVD-ROM drive.
- SVGA (1024 × 768) monitor (or higher resolution).
- Internet access required for web updates.
- Keyboard and mouse, or a compatible pointing device.

Microsoft Windows Vista, Windows 7 and Windows 8:

- Personal computer with a 1 GHz 32-bit (x86) processor.
- 1 GB of RAM.
- 40 GB hard disk, with at least 15 GB of available hard disk space.
- DVD-ROM drive.
- Support for DirectX 9 graphics with:
  - WDDM driver
  - 128 MB of graphics memory (minimum)
  - Pixel Shader 2.0 in hardware
  - 32 bits per pixel.
- SVGA (1024 × 768) monitor (or higher resolution).
- Internet access (fees may apply).
- Audio output.
- Keyboard and mouse, or a compatible pointing device.

5.2 Installation of Flir Tools/Tools+

5.2.1 Windows XP installation

Note

Before you install Flir Tools/Tools+, do the following:

1. Close all programs.
2. Uninstall any previous versions of Flir Tools/Tools+.
3. Uninstall any drivers and language packs related to Flir Tools/Tools+.

5.2.1.1 Procedure

Follow this procedure:

1. Insert the Flir Tools/Tools+ installation CD/DVD into the CD/DVD drive. The installation should start automatically.
   If the installation does not start automatically, follow this procedure:
   1. Double-click *My Computer* on the *Desktop*.
   2. Right-click the CD/DVD drive and click *Explore*.
   3. Double-click SETUP.EXE.
   4. Go to Step 2 below.
2. Flir Tools/Tools+ requires some prerequisites.
   If they are not already installed on your computer, click *OK* when asked if you want to install the software.
3. Flir Tools/Tools+ requires Microsoft .NET Framework 4.0.
   If this software is not already installed on your computer, click *OK* when asked if you want to install the software.

   Installation of Microsoft .NET Framework 4.0 can take several minutes.
4. In the Flir Tools/Tools+ installation wizard dialog box, click *Next*.
5. In the license agreement dialog box, carefully read and accept the license agreement and click *Next*.
6. In the customer information dialog box, enter your customer details and click *Next*.
7. Click *Install*.
8. Click *Finish*.
   If you are asked to restart your computer, do so.

5.2.2 Windows Vista, Windows 7 and Windows 8 installation

Note
Before you install Flir Tools/Tools+, close all programs.

5.2.2.1 Procedure

Follow this procedure:

1. Insert the Flir Tools/Tools+ installation CD/DVD into the CD/DVD drive. The installation should start automatically.
2. In the *Autoplay* dialog box, click *Run setup.exe (Published by Flir Systems)*.
3. In the *User Account Control* dialog box, confirm that you want to install Flir Tools/Tools+.
4. In the *Ready to Install the Program* dialog box, click *Install*.
5. Click *Finish*. The installation is now complete. If you are asked to restart your computer, do so.

6 Enabling Flir Tools+

Flir Tools+ adds a number of features to Flir Tools, such as recording and play-back of radiometric video files, time–temperature plotting, Microsoft Word reporting, grouping of files, stitching of images into panoramas, and more.

To enable Flir Tools+, follow this procedure:

1. On the *Help* menu, click *License options*.
2. For Flir Tools+, click *Apply*.
3. Restart the program.
   A 30-day evaluation version of Flir Tools+ has now begun. If you want to use the program after 30 days, you need to purchase it.

For more information, see section 7.4 *Activating additional software modules*, page 13.

7 Managing licenses

7.1 Registering your product

7.1.1 General

It is important that you register your product. By registering your product you are entitled to:

- Free program updates.
- Free unlimited technical support at http://support.flir.com.
- Timely information about new releases.

7.1.2 Figure

Figure 7.1 Registration form.

7.1.3 Procedure

Note
Your computer needs to have Internet access during this procedure.

Follow this procedure:

To register your product, fill in the required fields and click *Register*.

7.2 Activating your license

7.2.1 General

The first time you start Flir Tools/Tools+ you will be able to choose one of the following options:

- Activate Flir Tools/Tools+ online.
- Activate Flir Tools/Tools+ by e-mail.
- Purchase Flir Tools/Tools+ and receive a serial number for activation.
- Use Flir Tools/Tools+ for free during an evaluation period.

7.2.2 Figure

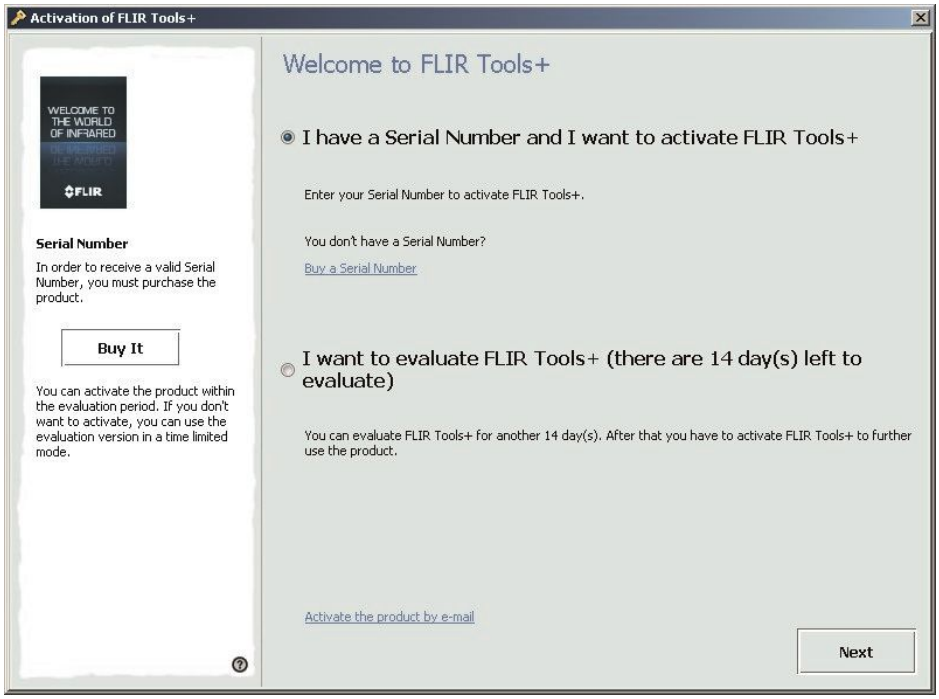

Activation of FLIR Tools+
WELCOME TO THE WORLD OF INFRARED
FLIR
Serial Number
In order to receive a valid Serial Number, you must purchase the product.
Buy It
You can activate the product within the evaluation period. If you don't want to activate, you can use the evaluation version in a time limited mode.
Welcome to FLIR Tools+
I have a Serial Number and I want to activate FLIR Tools+
Enter your Serial Number to activate FLIR Tools+.
You don't have a Serial Number?
Buy a Serial Number
I want to evaluate FLIR Tools+ (there are 14 day(s) left to evaluate)
You can evaluate FLIR Tools+ for another 14 day(s). After that you have to activate FLIR Tools+ to further use the product.
Activate the product by e-mail
Next

Figure 7.2 Activation dialog box.

7.2.3 Activating Flir Tools/Tools+ online

Note
Your computer needs to have Internet access during this procedure.

Follow this procedure:

1. Start Flir Tools/Tools+.
2. In the web activation dialog box, select *I have a Serial Number and I want to activate Flir Tools/Tools+*.
3. Click *Next*.
4. Enter your serial number, name, company and e-mail address. The name should be that of the license holder.
5. Click *Next*.
6. Click *Activate now*. This will start the web activation process.
7. When the message *Online activation was successful* is displayed, click *Close*. You have now successfully activated Flir Tools/Tools+.

7.2.4 Activating Flir Tools/Tools+ by e-mail

Note
Your computer needs to have Internet access during this procedure.

Follow this procedure:

1. Start Flir Tools/Tools+.
2. In the web activation dialog box, click *Activate the product by e-mail*.
3. Enter your serial number, name, company and e-mail address. The name should be that of the license holder.
4. Click *Request Unlock Key by E-mail*.

5. Your default e-mail client now opens and an unsent e-mail with the license information is displayed.

   Note
   Send this e-mail without altering the content.

   The main purpose of the e-mail is to send the license information to the activation center.

6. Click *Next*. The program will now start and you can continue working while waiting for the unlock key. You should receive an e-mail with the unlock key within two days.
7. When the e-mail with the unlock key arrives, start the program and enter the unlock key in the text box. See the figure below.

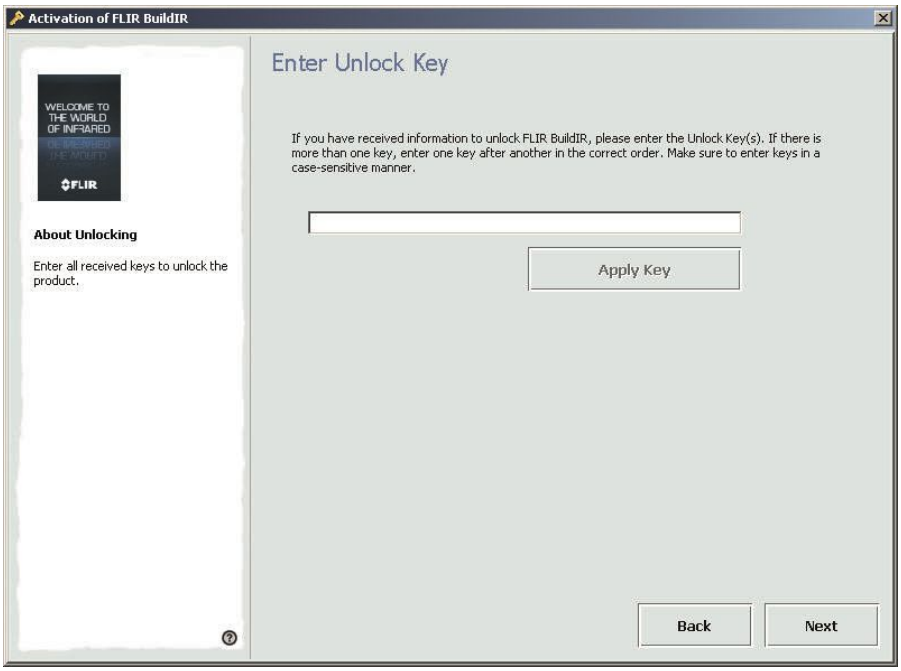

Activation of FLIR BuildIR
WELCOME TO THE WORLD OF INFRARED
FLIR
About Unlocking
Enter all received keys to unlock the product.
Enter Unlock Key
If you have received information to unlock FLIR BuildIR, please enter the Unlock Key(s). If there is more than one key, enter one key after another in the correct order. Make sure to enter keys in a case-sensitive manner.
Apply Key
Back
Next

Figure 7.3 Unlock key dialog box.

7.3 Transferring your license

7.3.1 General

You can transfer a license from one computer to another computer, as long as you do not exceed the number of purchased licenses.

This lets you use the software on, for example, a desktop and a laptop computer.

7.3.2 Figure

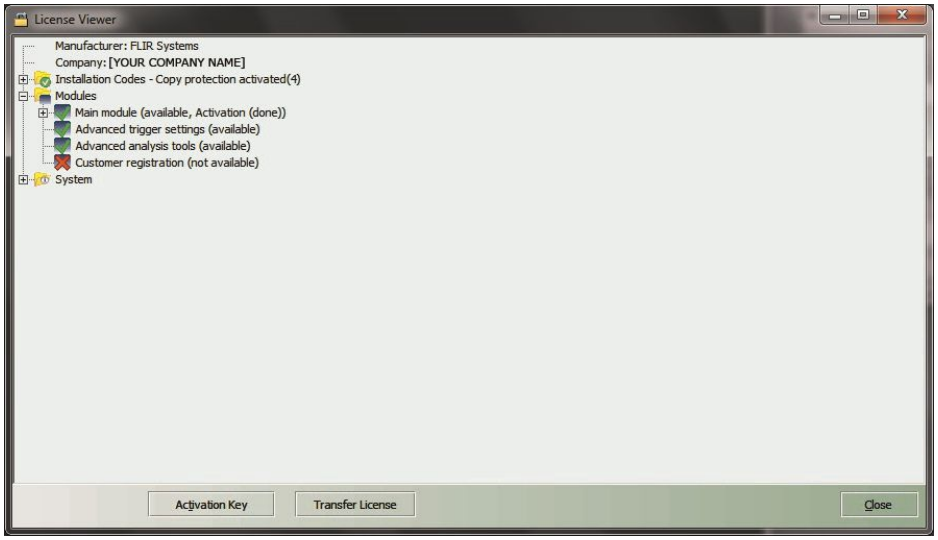


Figure 7.4 License viewer (example image only).

7.3.3 Procedure

Note
Your computer needs to have Internet access during this procedure.

Follow this procedure:

1. Start Flir Tools/Tools+.
2. On the *Help* menu, select *Show license information*. This will display the license viewer shown above.
3. In the license viewer, click *Transfer license*. This will display a deactivation dialog box.
4. In the a deactivation dialog box, click *Deactivate*.
5. On the computer to which you want to transfer the license, start Flir Tools/Tools+. As soon as the computer gets Internet access, the license will be automatically adopted.

Note
The adoption of licenses is based on a “first-come, first-serve” concept. This means that the *first* computer that gets Internet access automatically adopts the transferred license.

7.4 Activating additional software modules

7.4.1 General

For some software, you can purchase additional modules from Flir Systems. Before your can use the module, you need to activate it.

7.4.2 Figure

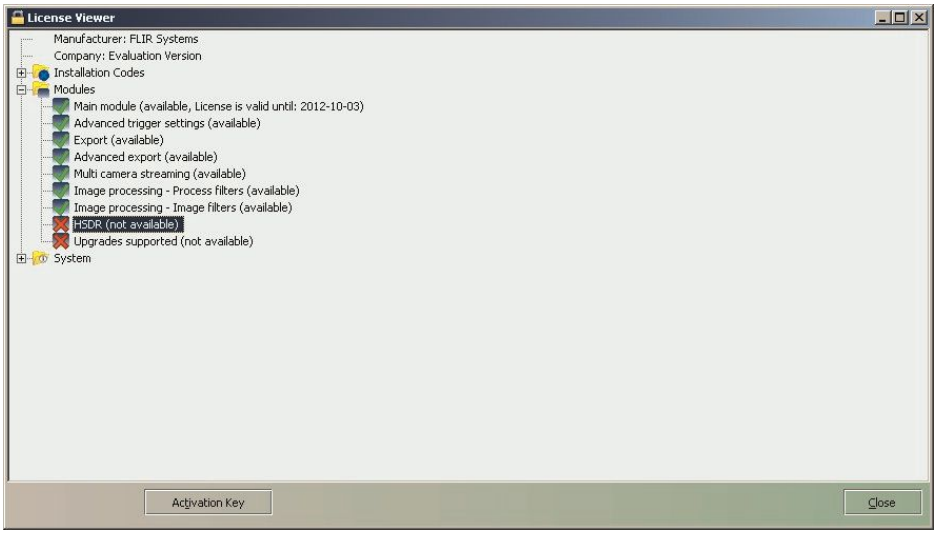


Figure 7.5 License viewer, showing available software modules (example image only).

7.4.3 Procedure

Note
Your computer needs to have Internet access during this procedure.

Follow this procedure:

1. Download and install the software module. Software modules are typically delivered as printed scratchcards with a download link.
2. Start Flir Tools/Tools+.
3. On the *Help* menu, select *Show license information*. This will display the license viewer shown above.
4. Select the module that you have purchased.
5. Click *Activation Key*.
6. On the scratchcard, scratch the field to see the activation key.
7. Enter the key into the *Activation Key* text box.
8. Click OK.
   The software module has now been activated.

8 Workflow

8.1 General

When you carry out an infrared inspection you follow a typical workflow. This section gives an example of an infrared inspection workflow.

8.2 Figure

8.3 Explanation

1. Use your camera to take your infrared images and/or digital photos.
2. Connect your camera to a PC using a USB connector.
3. Import the images from the camera into Flir Tools/Tools+.
4. Do one of the following:
   - Create a PDF report in Flir Tools.
   - Create a Microsoft Word report in Flir Tools+.
5. Send the report to your client as an attachment to an e-mail.

9 Importing images

9.1 Procedure

Follow this procedure:

1. Install Flir Tools/Tools+ on your computer.
2. Start Flir Tools/Tools+.
3. Turn on the camera.
4. Connect the camera to the computer, using a USB cable. This displays an import guide.

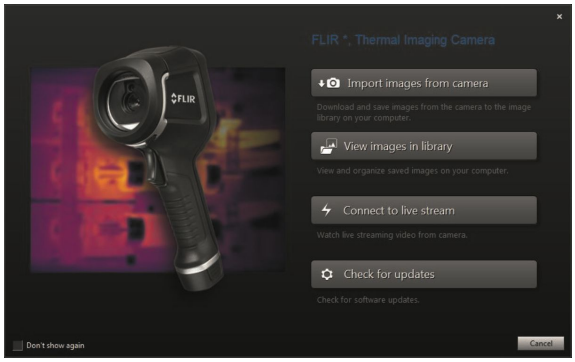

FLIR *, Thermal Imaging Camera
Import images from camera
Download and save images from the camera to the image library on your computer.
View images in library
View and organize saved images on your computer.
Connect to live stream
Watch live streaming video from camera.
Check for updates
Check for software updates.
Don't show again
Cancel

Figure 9.1 Import guide (example).

Note
For some older camera models, you need to set the USB mode to *mass storage device* (MSD) or *mass storage device—UVC* (MSD-UVC).

5. Click *Import images from camera* and follow the on-screen instructions to move the images from the camera to a destination folder on your computer.

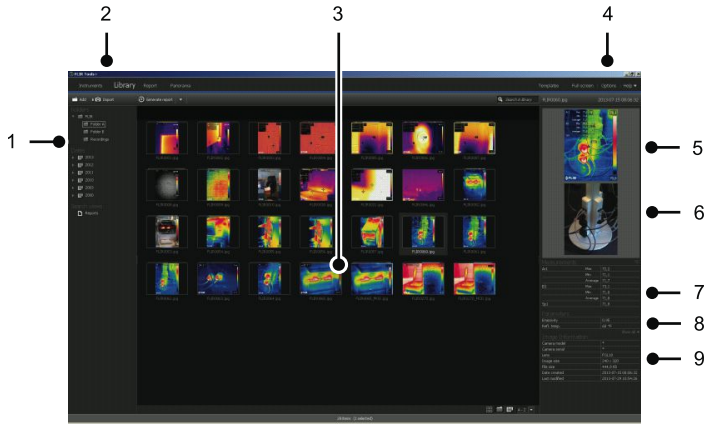
Note

- When the images are imported, all file associations will be kept. For example, if a digital photo is grouped together with an infrared image in the camera, this association will be retained in Flir Tools/Tools+. The same applies for text annotations, voice annotations, sketches, etc.
- Imported images will be saved by default under */My Documents/FLIR*.

10 Screen elements and toolbar buttons

10.1 Window elements: the *Library* tab

10.1.1 Figure



10.1.2 Explanation

1. Folder pane.
2. Program tabs:
   - *Instruments* (e.g., meters or infrared cameras).
   - *Library*.
   - *Report*.
   - *Panorama*.
3. Thumbnail view of selected folders.
4. Menu bar:
   - *Templates*.
   - *Full screen*.
   - *Options*.
   - *Help*.
5. Thumbnail view of the infrared image.
6. Thumbnail view of the digital photo (if available).
7. Measurement pane.

Note

A icon in the result table indicates that the measurement result is above or below the calibrated temperature range of the infrared camera and is therefore incorrect. This phenomenon is called *overflow* or *underflow*.

A icon in the result table indicates that the measurement result is too close to the calibrated temperature range of the infrared camera and is therefore unreliable.

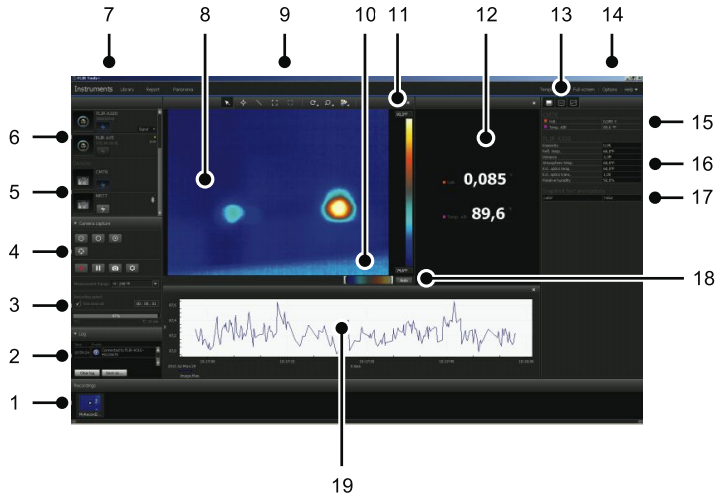
8. Parameters pane.
9. Image information pane

10.2 Window elements: the *Instruments* tab

Note

The *Instruments* tab will only become available when a camera in UVC mode or a MeterLink device is connected to the computer.

10.2.1 Figure



10.2.2 Explanation

1. Recordings pane.
2. Log area.
3. Recording speed and time interval controls.
4. Camera-related controls:
   - Focusing the camera.
   - Calibrating the camera.
   - Recording a sequence, pausing a sequence, and resuming a sequence.
   - Saving a single snapshot as a *.jpg file.
   - Selecting the measurement range.
   - In the *Options* dialog box (opens by clicking the button):
     - Setting the file name prefix.
     - Setting the storage location for sequence files (*.seq).
     - Setting the maximum amount of disk usage.
5. Button to connect to a Bluetooth-enabled device (e.g., a meter)
6. Button to connect a camera.
7. Program tabs.
8. Image window.
9. Toolbar buttons.
10. Sliders to adjust the bottom and top temperature levels in the scale.
11. Temperature scale.
12. Measurements window (results from the connected device, e.g., a meter)
13. Toolbar buttons:
    - Show/hide thermal camera view.
    - Show/hide measurements view.
    - Show/hide plot view.
14. Menu bar:
    - *Templates*.
    - *Full screen*.
    - *Options*.
    - *Help*.
15. Measurements and parameters pane (devices).

16. Measurements and parameters pane (thermal cameras).

Note

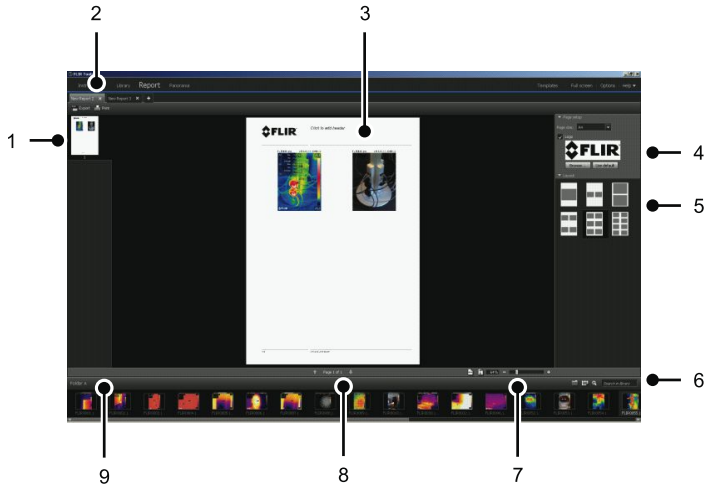
A icon in the result table indicates that the measurement result is above or below the calibrated temperature range of the infrared camera and is therefore incorrect. This phenomenon is called *overflow* or *underflow*.

A icon in the result table indicates that the measurement result is too close to the calibrated temperature range of the infrared camera and is therefore unreliable.

17. Annotations pane.
18. Auto-adjust button.
19. Plot window.

10.3 Window elements: the *Create imagesheet* tab

10.3.1 Figure

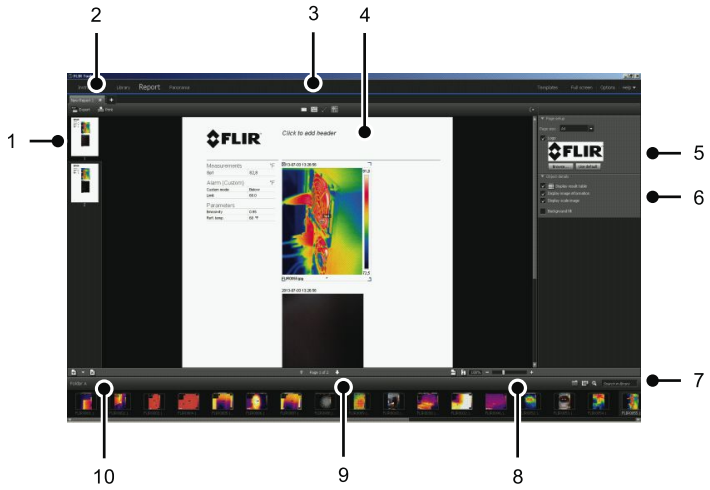


10.3.2 Explanation

1. Thumbnail view of the current page.
2. Tabs to go to the different imagesheets that are currently open.
3. Detail view of the current imagesheet page.
4. Page setup, where a company logo and the paper size can be selected.
5. Page layout setup.
6. Text box to search and filter the images.
7. Zoom controls.
8. Page controls.
9. Images in the currently selected folder.

10.4 Window elements: the *Report* tab

10.4.1 Figure

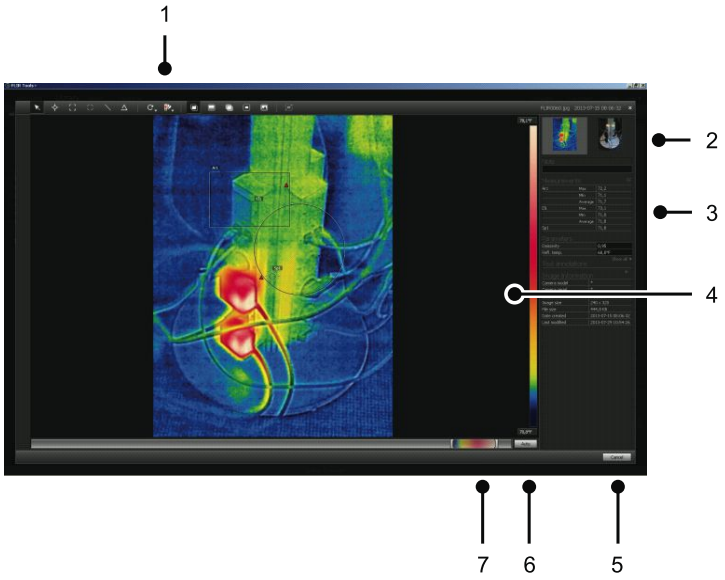


10.4.2 Explanation

1. Thumbnail view of the current report page.
2. Tabs to go to the different reports that are currently open.
3. Toolbar buttons.
4. Detail view of the current report page.
5. Page setup, where logos and paper size can be selected.
6. Area for image object details and voice comments.
7. Text box to search and filter the images.
8. Zoom controls.
9. Page controls.
10. Images in the currently selected folder.

10.5 Window elements: the image-editing window (for still images)

10.5.1 Figure

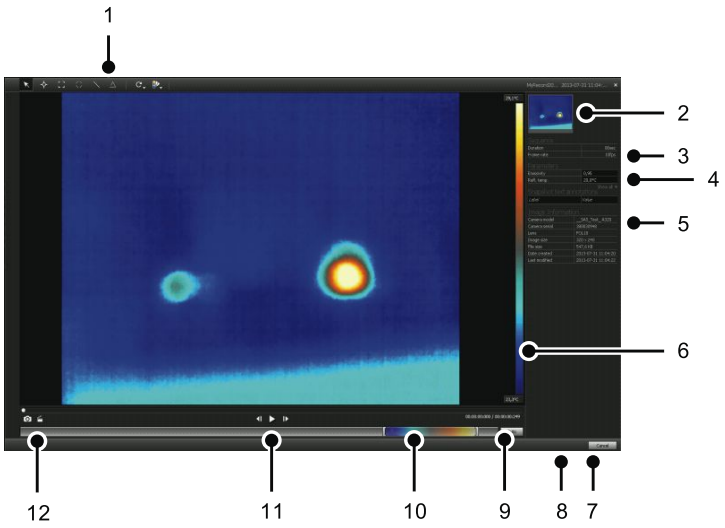


10.5.2 Explanation

1. Measurement toolbar.
2. Thumbnail view of the infrared image (and digital photo, if available).
3. Additional panes:
    - *Notes*.
    - *Measurements*.
    - *Parameters*.
    - *Text annotations*.
    - *Image information*.
4. Temperature scale.
5. Cancel button.
6. Auto-adjust button, to adjust the image for the best brightness and contrast.
7. Temperature span and level control.

10.6 Window elements: the image-editing window (for video clips)

10.6.1 Figure



10.6.2 Explanation

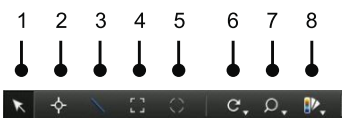
1. Measurement toolbar.
2. Thumbnail view of the video clip.
3. Information about the sequence file.
4. Measurement and parameters pane.
5. Image information pane.
6. Temperature scale.
7. Cancel button.
8. Save and close button.
9. Auto-adjust button, to adjust the image for the best brightness and contrast.
10. Temperature span and level control.
11. Play/pause and forward/backward buttons.
12. Buttons to save a snapshot as a *.jpg file and to export the video clip as an *.avi file.

Note
Exporting a video clip as an *.avi file requires that FFDShow has been installed on the computer. FFDShow can be downloaded from http://www.free-codecs.com.

10.7 Toolbar buttons (on the *Instruments* tab)

Note
The *Instruments* tab will only become available when a camera in UVC mode or a MeterLink device is connected to the computer.

10.7.1 Figure



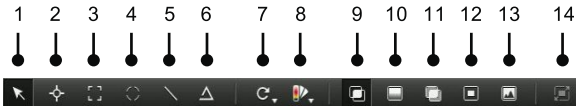
10.7.2 Explanation

1. Selection tool.
2. Spotmeter tool.
3. Line tool.

4. Area tool.
5. Circle and ellipsis tool.
6. Rotate right/left tool.
7. Zoom tool.
8. Color palette tool.

10.8 Toolbar buttons (in the image-editing window)

10.8.1 Figure

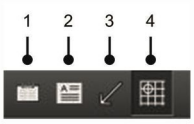


10.8.2 Explanation

1. Selection tool.
2. Spotmeter tool.
3. Area tool.
4. Circle and ellipsis tool.
5. Line tool.
6. Difference tool.
7. Rotate left/rotate right tool.
8. Color palette tool.
9. Thermal MSX tool.
10. Thermal tool.
11. Thermal fusion tool.
12. Picture-in-picture tool.
13. Digital photo tool.
14. Tool to change Picture-in-picture.

10.9 Toolbar buttons (in the report-editing window)

10.9.1 Figure

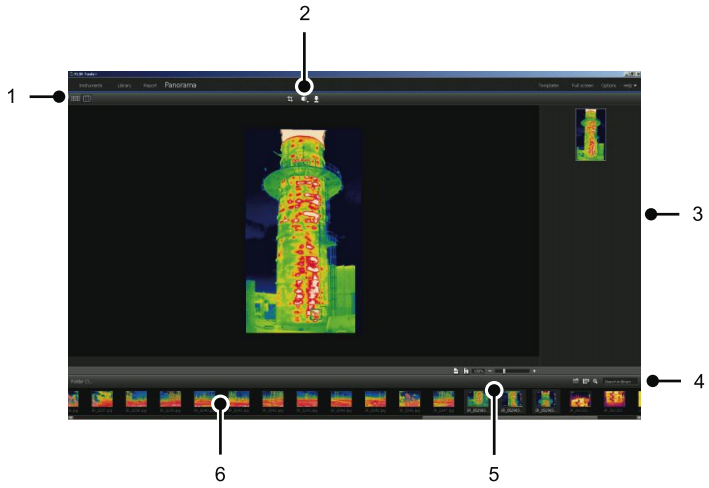


10.9.2 Explanation

1. Text annotation tool.
2. Textbox tool.
3. Arrow marker tool.
4. Snap objects to grid.

10.10 The *Panorama* tab

10.10.1 Figure



10.10.2 Explanation

1. Buttons to switch between source file view and panorama view.
2. Buttons to crop the panorama image, to correct the perspective, and to save the panorama image.
3. Pane where all panorama images created from the selected images are displayed.
4. Buttons to change the folder, select images by date, and search images.
5. Buttons to zoom into and out of the panorama image.
6. Pane displaying the source files in the currently selected folder.

11 Live image streaming of camera images

11.1 General

You can connect an infrared camera to Flir Tools/Tools+ and display its live image stream on the *Instruments* tab. When the camera is connected, you can lay out measurement tools, change parameters, create plots, etc.

11.2 Figure

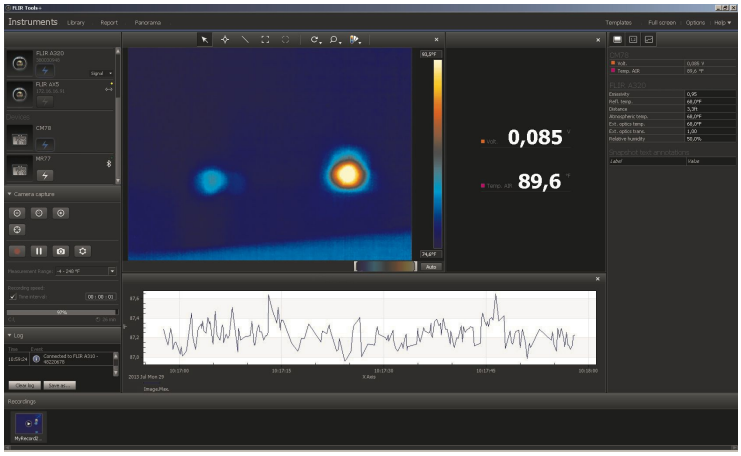


Figure 11.1 The *Instruments* tab.

11.3 Procedure

Follow this procedure:

1. Start Flir Tools/Tools+.
2. Turn on the infrared camera.
3. Connect the camera to the computer, using a USB cable. This displays an import guide.

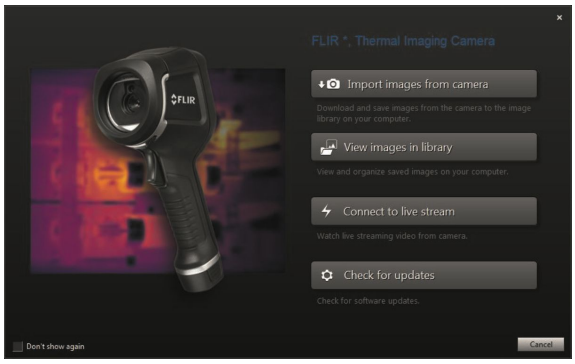

FLIR *, Thermal Imaging Camera
Import images from camera
Download and save images from the camera to the image library on your computer.
View images in library
View and organize saved images on your computer.
Connect to live stream
Watch live streaming video from camera.
Check for updates
Check for software updates.
Don't show again
Cancel

Figure 11.2 Import guide (example).

> **Note**
> For some older camera models, you need to set the USB mode to *mass storage device* (MSD) or *mass storage device—UVC* (MSD-UVC).

4. Click *Connect to livestream*. This displays the live image stream from the camera on the *Instruments* tab.

5. On the *Instruments* tab, do one or more of the following:
   - To adjust camera focus, click the button (near focus), the button (auto-focus), or the button (far focus).
   - To calibrate the camera, click the button.
   - To start a recording, click the button.
   - To stop a recording, click the button.
   - To freeze the live image stream, click the toolbar button.
   - To save a single snapshot as a *.jpg file, click the button.
   - To change a number of recording settings, click the button. This displays a dialog box.
   - To display the live image stream of another camera on the network, click the button for that camera.
   - To lay out a measurement tool, click the tool and then click on the image.
   - To change parameters, click the value field of a parameter, type a new value, and press Enter.
   - To create a plot, right-click the image and then select the type of plot you want.

Note
The *Instruments* tab will only become available when a camera in UVC mode or a MeterLink device is connected to the computer.

12 Managing images and folders

12.1 Grouping files

12.1.1 General

You can group files together, e.g., one infrared image and one digital photo, or one infrared image and a plot. When two files are grouped, a link is created and the images act as a pair through the reporting process.

12.1.2 Procedure

Follow this procedure:

1. Go to the *Library* tab.
2. In the image window, select two files.
3. Right-click the images and click *Group*.

12.2 Saving a sequence file frame as a radiometric *.jpg file

12.2.1 General

You can save a sequence file frame as a radiometric *.jpg image.

12.2.2 Procedure

Follow this procedure:

1. Go to the *Library* tab.
2. Double-click a sequence file (file suffix *.seq).
3. Go to the point of interest in the sequence file, using the playback controls.
4. Click the toolbar button. This will open a *Save as* dialog box where you can navigate to the location where you want to save the file.

12.3 Saving a sequence file frame as an *.avi file

12.3.1 General

You can save a sequence file frame as an *.avi file.

Note
Exporting a video clip as an *.avi file requires that FFDShow has been installed on the computer. FFDShow can be downloaded from http://www.free-codecs.com.

12.3.2 Procedure

Follow this procedure:

1. Go to the *Library* tab.
2. Double-click a sequence file (file suffix *.seq).
3. Click the toolbar button. This will open a *Save as* dialog box where you can navigate to the location where you want to save the file.

12.4 Deleting images

12.4.1 General

You can delete one image or a group of images.

12.4.2 Procedure

Follow this procedure:

1. Go to the *Library* tab.
2. In the image window, select the image or images that you want to delete.

3. Do one of the following:
   - Press the DELETE key and confirm that you want to delete the image or images.
   - Right-click the image or images, select *Delete*, and confirm that you want to delete the image or images.

Note

- When you delete an image or a group of images, you can restore them from the computer's Recycle Bin.
- You can also remove images by deleting the path under *Options* > *Library*. Removing the path does not delete the images.

12.5 Adding a directory

12.5.1 General

You can add a directory to the library.

12.5.2 Procedure

Follow this procedure:

1. Go to the *Library* tab.
2. At the top of the left pane, click *Add to library*. This will open a *Browse for folder* dialog box where you can navigate to the directory that you want to add.

Note

Only subdirectories can be deleted. Root directories can only be removed by deleting the path under *Options* > *Library*. Removing the path does not delete the images.

12.6 Deleting a directory

12.6.1 General

You can delete a directory from the library.

12.6.2 Procedure

Follow this procedure:

1. Go to the *Library* tab.
2. Right-click a directory and select *Delete directory*.

Note

Only subdirectories can be deleted. Root directories can only be removed by deleting the path under *Options* > *Library*. Removing the path does not delete the images.

12.7 Creating a subfolder

12.7.1 General

You can create a subfolder to an existing directory in the library.

12.7.2 Procedure

Follow this procedure:

1. Go to the *Library* tab.
2. Right-click a directory and select *Create subfolder*.

13 Analyzing images

13.1 Laying out a measurement tool

13.1.1 General

You can lay out one or more measurement tools on an image, e.g., a spotmeter, an area, a circle, or a line.

Note

A icon in the result table indicates that the measurement result is above or below the calibrated temperature range of the infrared camera and is therefore incorrect. This phenomenon is called *overflow* or *underflow*.

A icon in the result table indicates that the measurement result is too close to the calibrated temperature range of the infrared camera and is therefore unreliable.

13.1.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. On the image toolbar, select a measurement tool.
3. To lay out the measurement tool on the image, click the location where the measurement tool is to be placed.

Note

You can also do this by double-clicking an image on a report page and then following the procedure above. In this case, only the image in the report will be changed, not the image in the library.

13.2 Moving a measurement tool

13.2.1 General

Measurement tools that you have laid out on an image can be moved around, using the selection tool.

13.2.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. On the image toolbar, select .
3. On the image, select the measurement tool and drag it to a new position.

Note

Measurement tools can also be moved on report pages. In this case, only the image in the report will be changed, not the image in the library.

13.3 Resizing a measurement tool

13.3.1 General

Measurement tools that you have laid out on an image, e.g., an area, can be resized using the selection tool.

13.3.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. On the image toolbar, select .

3. On the image, select the measurement area and use the selection tool to drag the handles that are displayed around the frame of the area:

Note
Measurement tools can also be resized on report pages. In this case, only the image in the report will be changed, not the image in the library.

13.4 Deleting a measurement tool

13.4.1 General

You can delete any measurement tools that you have laid out on an image.

13.4.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. On the image toolbar, select .
3. On the image, select the measurement tool and press DELETE.

13.5 Working with isotherms

13.5.1 General

The isotherm command applies a contrasting color to all pixels with a temperature above, below, or between one or more set temperature levels.

Using isotherms is a good method to easily discover anomalies in an infrared image.

13.5.2 Setting up general isotherms (Above, Below)

13.5.2.1 General

An isotherm of the type *Above* and *Below* will colorize areas with a temperature *above* or *below* a set temperature.

13.5.2.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. On the image toolbar, click , and select one of the following:
   - *Above*.
   - *Below*.
3. In the right pane, take note of the parameter *Limit*. Areas in the image with a temperature *above* or *below* this temperature will be colorized with the isotherm color. You can change this limit, and also change the isotherm color on the *Color* menu.

13.5.3 Setting up general isotherms (Interval)

13.5.3.1 General

An isotherm of the type *Interval* will colorize areas with a temperature *between* two set temperatures.

13.5.3.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. On the image toolbar, click , and select *Interval*.
3. In the right pane, take note of the parameters *Upper limit* and *Lower limit*. Areas in the image with a temperature between these two temperatures will be colorized with the isotherm color. You can change these limits, and also change the isotherm color on the *Color* menu.

13.5.4 Setting up a humidity isotherm

13.5.4.1 General

The humidity isotherm can detect areas where there is a risk of mold growing, or where there is a risk of the humidity falling out as liquid water (i.e., the dew point).

13.5.4.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. On the image toolbar, click , and select *Humidity*. Depending on your object, certain areas will now be colorized with an isotherm color.
3. In the right pane, take note of the parameter *Calculated limit*. This is the temperature at which there is a risk of humidity. If the parameter *Relative humidity limit* is set to 100%, this is also the *dew point*, i.e., the temperature at which the humidity falls out as liquid water.

Note

The parameter *Calculated limit* takes the following three parameters into account:

- Relative humidity.
- Relative humidity limit.
- Atmospheric temperature.

13.5.5 Setting up an insulation isotherm

13.5.5.1 General

The insulation isotherm can detect areas where there may be an insulation deficiency in the building. It will trigger when the insulation level falls below a preset value of the energy leakage through the building structure—the so-called *thermal index*.

Different building codes recommend different values for the thermal index, but typical values are 0.6–0.8 for new buildings. Refer to your national building code for recommendations.

13.5.5.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.

2. On the image toolbar, click , and select *Insulation*. Depending on your object, certain areas will now be colorized with an isotherm color.
3. In the right pane, take note of the parameter *Calculated insulation*. This is the temperature where the insulation level falls below a preset value of the energy leakage through the building structure.

Note
The parameter *Calculated insulation* takes the following three parameters into account:

- Indoor temperature.
- Outdoor temperature.
- Thermal index.

13.5.6 Setting up a custom isotherm

13.5.6.1 General

A custom isotherm is an isotherm of any of the following types:

- *Above*.
- *Below*.
- *Interval*.
- *Humidity*.
- *Insulation*.

For these custom isotherms, you can specify a number of different parameters manually, compared with using the standard isotherms:

- *Background*.
- *Colors* (semi-transparent or solid colors).
- *Inverted color* (for the *Interval* isotherm only).

13.5.6.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. On the image toolbar, click , and select *Custom*.

3. In the right pane, specify the following parameters:
   - For *Above* and *Below*:
     - *Background*.
     - *Limit*.
     - *Color*.
   - For *Interval*:
     - *Background*.
     - *Upper limit*.
     - *Lower limit*.
     - *Color*.
     - *Inverted interval*.
   - For *Humidity*:
     - *Background*.
     - *Color*.
     - *Relative humidity*.
     - *Relative humidity limit*.
     - *Atmospheric temperature*.
   - For *Insulation*:
     - *Background*.
     - *Color*.
     - *Indoor temperature*.
     - *Outdoor temperature*.
     - *Thermal index*.

13.6 Changing the temperature levels

13.6.1 General

At the bottom of the infrared image you will see two sliders. By dragging these sliders to the left or to the right you can change the top and bottom levels in the temperature scale.

13.6.2 Why change temperature levels?

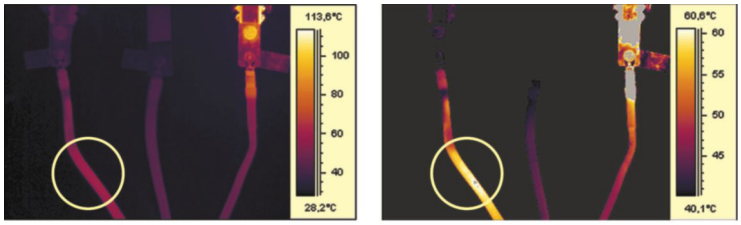
The reason to change the temperature levels manually is that it makes it easier to analyze a temperature anomaly.

13.6.2.1 Example 1

This figure shows two infrared images of cable connection points. In the left image, a correct analysis of the circled cable is difficult if you only auto-adjust the image. You can analyze this cable in more detail if you:

- Change the temperature scale level.
- Change the temperature scale span.

In the left image, the image is auto-adjusted. In the right image, the maximum and minimum temperature levels have been changed to temperature levels near the object. On the temperature scale to the right of each image you can see how the temperature levels were changed.

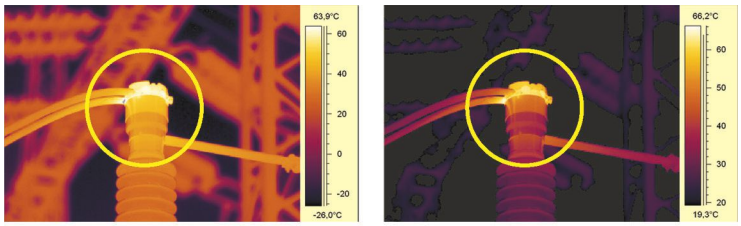


A (automatic) M (manual)

13.6.2.2 Example 2

This figure shows two infrared images of an isolator in a power line.

In the left image, the cold sky and the power line structure are recorded at a minimum temperature of –26.0°C (–14.8°F). In the right image, the maximum and minimum temperature levels have been changed to temperature levels near the isolator. This makes it easier to analyze the temperature variations in the isolator.



A (automatic) M (manual)

13.6.3 Changing the top level

Follow this procedure:

1. Drag the right slider right or left to change the top level in the temperature scale.

13.6.4 Changing the bottom level

Follow this procedure:

1. Drag the left slider right or left to change the bottom level in the temperature scale.

13.6.5 Changing both the top and bottom levels at the same time

Follow this procedure:

1. SHIFT-drag the left or right slider right or left to change both the top and the bottom levels in the temperature scale at the same time.

Note

- You can adjust the temperature levels by using the mousewheel.
- You can adjust the temperature span by holding down the CTRL key while using the mousewheel.
- You can double-click the temperature levels scale to auto-adjust the image.
- You can change the temperature levels by double-clicking an image on a report page and then dragging the sliders. In this case, only the image in the report will be changed, not the image in the library.

13.7 Auto-adjusting an image

13.7.1 General

You can auto-adjust an image or a group of images. When you auto-adjust an image you adjust it for the best image brightness and contrast.

13.7.2 Procedure

Follow this procedure:

1. To auto-adjust an image, do one of the following:
   - Double-click the temperature scale.

   - Click the *Auto* button.

Note
You can also do this by double-clicking an image on a report page and then following the procedure above. In this case, only the image in the report will be changed, not the image in the library.

13.8 Changing the palette

13.8.1 General

You can change the palette that the camera uses to display the different temperatures within an image. A different palette can make it easier to analyze the image.

13.8.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. In the image window, click the button on the top toolbar. This will display a drop-down menu.
3. On the menu, click the palette that you want to use.

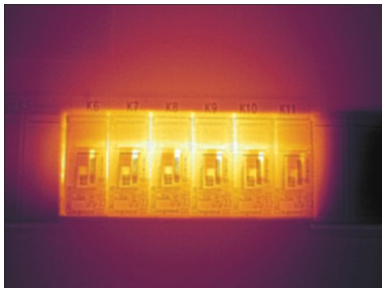
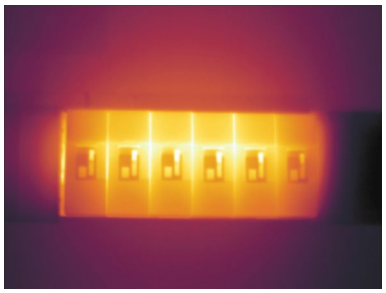
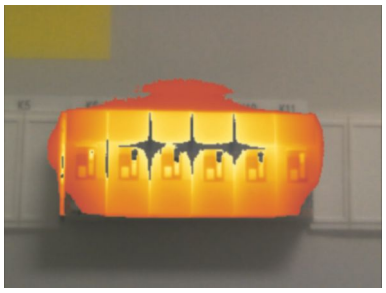
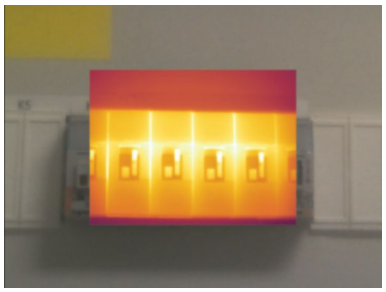
Note
You can also do this by double-clicking an image on a report page and then following the procedure above. In this case, only the image in the report will be changed, not the image in the library.

13.9 Changing the image mode

13.9.1 General

For some images you can change the image mode. You do this on the toolbar in the image-editing window.

13.9.2 Types of image modes

Button	Image mode	Image example
	Thermal MSX (Multi Spectral Dynamic Imaging): This mode displays an infrared image where the edges of the objects are enhanced. Note that the label for each fuse is clearly legible.	
	Thermal: This mode displays a fully infrared image.	
	Thermal fusion: This mode displays a digital photo where some parts are displayed in infrared, depending on the temperature limits.	
	Picture-in-picture: This mode displays an infrared image frame on top of a digital photo.	
	Digital camera: This mode displays a fully digital photo.	

13.10 Exporting temperature values as comma-separated values

13.10.1 General

You can export temperature values as a matrix of comma-separated values for further analysis in external software. The file format is *.csv, and the file can be opened in Microsoft Excel.

13.10.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. Right-click the image and select *Export image as *.csv file*.
   You can now open the file in Microsoft Excel.

14 Working with annotations

14.1 About image descriptions

14.1.1 What is an image description?

An image description is a brief free-form textual description that is stored in an infrared image file. It uses a standard tag in the *.jpg file format and can be retrieved by other software.

14.1.1.1 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. In the right pane, type the image description in the field under *Image description*.

Note
You can edit existing image descriptions on the final report pages, but you cannot create new image descriptions there.

14.2 About text annotations

14.2.1 What is a text annotation?

A *text annotation* is textual information about something in an image and is constructed of a group of information pairs—*label* and *value*. The reason for using text annotations is to make reporting and post-processing more efficient by providing essential information about the image, e.g., conditions, photos, and information about where an image is taken.

A text annotation is a proprietary annotation format from FLIR Systems, and the information cannot be retrieved by other vendors' software. The concept relies heavily on *interaction by the user*. In the camera, the user can select one of several values for each label. The user can also enter numerical values, and make the text annotation capture measurement values from the screen.

14.2.2 Definition of label and value

The concept of *text annotation* is based on two important definitions—*label* and *value*. The following examples explain the difference between the two definitions.

Company	Company A Company B Company C
Building	Workshop 1 Workshop 2 Workshop 3
Section	Room 1 Room 2 Room 3
Equipment	Tool 1 Tool 2 Tool 3
Recommendation	Recommendation 1 Recommendation 2 Recommendation 3

Note

- In some cameras and software, *text annotation* is called *text comment* or *table*.
- In some cameras and software, *label* is called *field*.

14.2.3 Example markup structure

The file format for a text annotation is *.tcf. This code sample is an example markup structure of such a file and shows how the markup looks in Notepad. The words between pointed brackets are labels, and the words without pointed brackets are values.

```
<Company>
Company A
Company B
Company C
<Building>
Workshop 1
Workshop 2
Workshop 3
<Section>
Room 1
Room 2
Room 3
<Equipment>
Machine 1
Machine 2
Machine 3
<Recommendation>
Recommendation 1
Recommendation 2
Recommendation 3
```

14.2.4 Creating a text annotation for an image

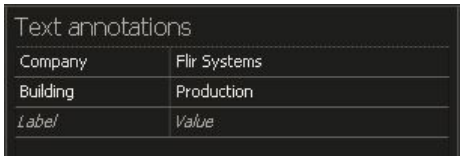
14.2.4.1 General

In Flir Tools/Tools+, you can create a text annotation for an image. You do this in the image-editing window.

14.2.4.2 Procedure

Follow this procedure:

1. On the *Library* tab, double-click an image.
2. Under *Text annotations* in the right pane, click the button (the '+' sign). This adds text annotation rows.
3. Enter the desired labels and values. See the image below for examples.



4. Click *Save and close*.

14.2.5 Creating a text annotation template

14.2.5.1 General

In Flir Tools/Tools+, you can create a text annotation template and transfer this text annotation to your camera. You do this on the *Templates* tab.

14.2.5.2 Procedure

Follow this procedure:

1. Click the *Templates* tab.
2. Click the *Add new text annotations template* toolbar button.
3. Create a name for the template.
4. Enter the desired fields and values. See the image below for examples.

5. Connect a camera to Flir Tools/Tools+.
   You can now transfer the text annotations template to the camera and use it as a template for further text annotations.

15 Creating panoramas

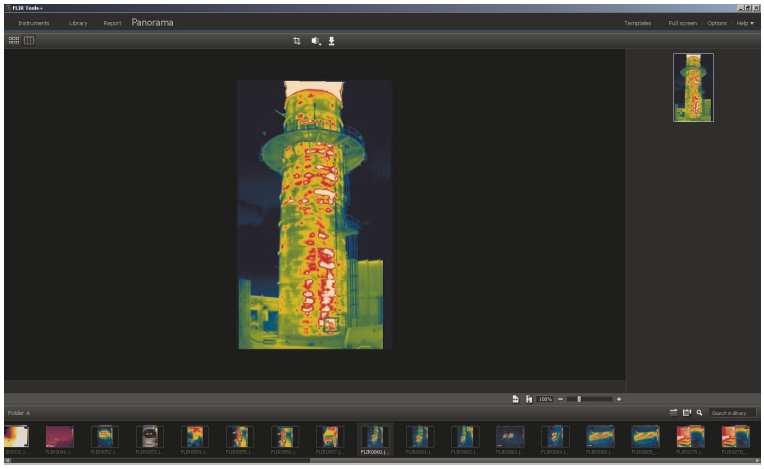
15.1 General

In Flir Tools+ you can create panoramas by stitching together several smaller images into a larger one. Flir Tools+ analyzes each image to detect pixel patterns that match pixel patterns in other images.

You can then crop the panorama and carry out various perspective corrections.

15.2 Figure

This figure shows the panorama workspace.



15.3 Procedure

Follow this procedure:

1. On the *Library* tab, select the images that you want to use when creating a panorama.
2. Right-click the images and select *Combine into panorama*. This will open the *Panorama* tab.
3. At this stage you can perform a variety of tasks:
   - Click to crop the panorama.
   - Click to carry out a perspective correction on the image.
   - Click to save the panorama as an image file.
   - Click to view the original source files.
   - Click to view the final panorama.

For more information, see section 10.10 *The Panorama tab*, page 24.

16 Creating an imagesheet

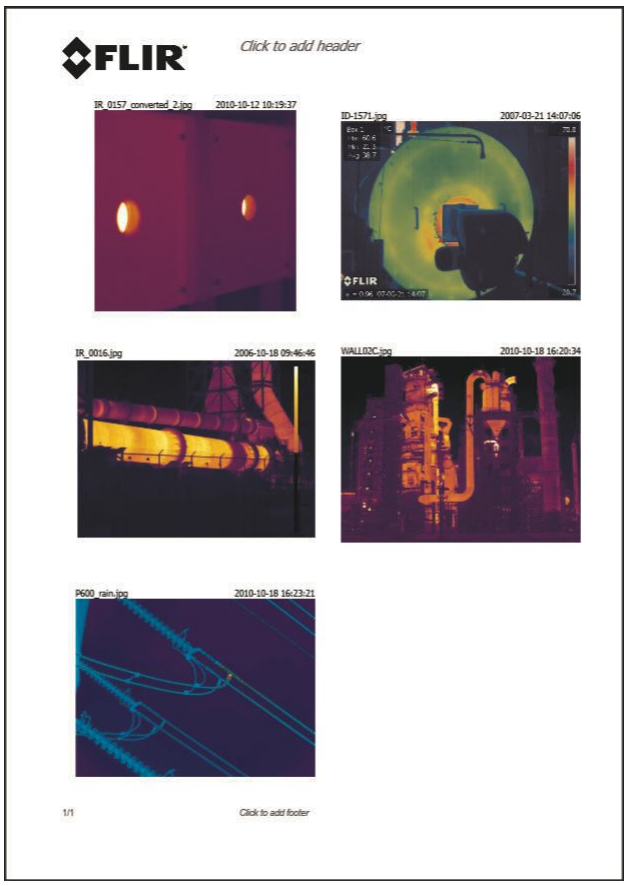
16.1 General

You can create an imagesheet of one or more images in your folders.

The imagesheets are saved in Adobe PDF format. To download the free reader, go to:

http://www.adobe.com/products/reader/

16.2 Figure



16.3 Procedure

Follow this procedure:

1. On the *Library* tab, select the image or images that you want to include in your imagesheet.
2. Right-click the image or images and select *Create imagesheet*.
3. Under *Page setup* on the right pane, select the page size and logo that you want to use.
4. Under *Layout* on the right pane, click the page layout that you want to use.
5. On the imagesheet, double-click the header and/or footer to add any header/footer text that you want to use.
6. Click *Export* to export the imagesheet as a PDF file.

17 Creating reports

17.1 General

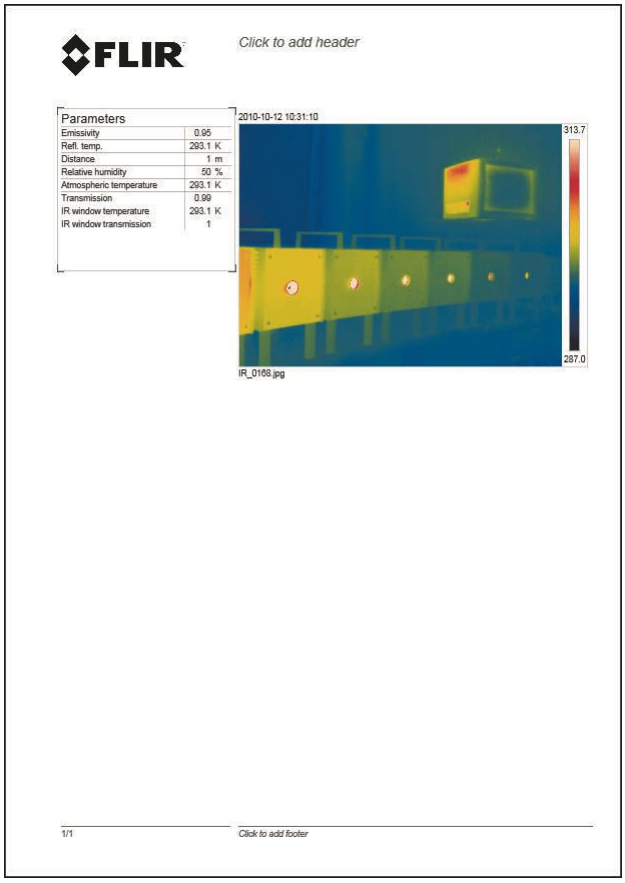
You can create a report on one or more images in your folders.

The reports are saved in Adobe PDF format. To download the free reader, go to:

http://www.adobe.com/products/reader/

For Flir Tools+, reports can also be generated as Microsoft Word documents. Advanced analysis can then be carried out using the Flir Tools+ features in Microsoft Word.

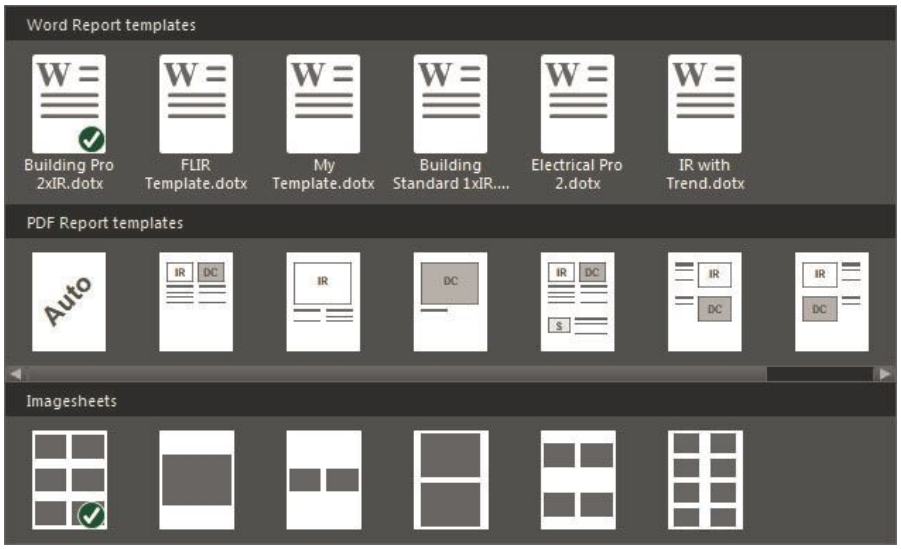
17.2 Figure



17.3 Procedure: setting a default report template

Follow this procedure:

1. On the *Library* tab, click . This will display the available report templates.



2. Right-click a report template and click *Set as default report template*.

17.4 Procedure: PDF reports

Follow this procedure:

1. On the *Library* tab, select the image or images that you want to include in your report.
2. Right-click the image or images and select *Create report*.
3. Under *Page setup* on the right pane, select the page size and logo that you want to use.
4. On the report, double-click the header and/or footer to add any header/footer text that you want to use.
5. Click *Export* to export the report as a PDF file.

17.5 Common tasks relating to PDF reports

In addition to simply generating a report, you can perform a variety of tasks in the report view:

- Drag a group of images, photos, and text annotations into a report.
- Drag single images, photos, and tables into a report.
- Reorder the pages in the report.
- Enter text in a report using textboxes.
- Create and edit text annotations.
- Edit image descriptions.
- Add and edit a header or footer in a report.
- Move and delete images, photos, text annotations, and tables in a report.
- Resize images in a report.
- Update measurements in an infrared image and see updates instantly in the result table.
- Zoom into and out of a report page.
- Add arrow markers to the image or any other object in the report.
- Edit an image from the report by double-clicking the image.

17.6 Procedure: Microsoft Word reports

Follow this procedure:

1. On the *Library* tab, select the image or images that you want to include in your report.
2. Right-click the image or images and select *Create report*.
3. The report is now generated and will open in Microsoft Word.
4. If you used one of the standard Microsoft Word templates when you generated the report, the following dialog box will now be displayed:

5. In the dialog box, enter customer information and information about the inspection in the right column. Use the TAB key to go between fields.
6. Click OK. The information you entered in this dialog box will now populate the corresponding placeholders in the report.

Note

This workflow assumes that the report properties are prefixed with an underscore (_), as they are for the standard report templates.

However, if you have created your own custom templates, you may have created report properties with a different prefix, e.g., using a percentage sign (%), a dollar sign ($), a hash sign (#), or the whole or part of your company name (e.g., “ACME”). To have these properties show up when you have generated the report, you need to update the property *FLIR_ReportPropertyPrefix* in Microsoft Word. For more information about this, see section 18.3.4 *Changing the prefix for a report property*, page 64

For in-depth information about how to work with reports in Microsoft Word, see section 18 *Working in the Microsoft Word environment*, page 46.

18 Working in the Microsoft Word environment

18.1 Creating a report template

18.1.1 General

Flir Tools+ ships with several different report templates (Microsoft Word *.dotx files). If these templates do not meet your needs, you can create your own custom infrared report templates.

18.1.1.1 Few or many report templates?

It is not uncommon that you will use one specific template for one specific customer. If this is the case, you may want to include your customer's company-specific information in the template, rather than entering it manually after the infrared report has been generated.

However, if several of your customers request an infrared report that could be met using one template, or just a few, company-specific information should probably not be included in the template, since that kind of information may easily be entered after the report has been generated.

18.1.1.2 Typical structure

A custom infrared report template usually consists of the following types of pages:

- A front cover.
- A number of different pages, containing combinations of IR Viewer objects, Digital Photo objects, IR Histogram objects, IR Profile objects, Table objects, Summary Table objects, etc.
- A back cover.

You create the front and back covers of the report template using existing features in Microsoft Word.

The front and back covers of an infrared report template typically include the following information:

- Your and your customer's company names.
- Other contact information.
- The current date.
- The title of the infrared report.
- Your and your customer's company logos.
- Any additional artwork or information that you may want to include.

18.1.1.3 A note about working in the Microsoft Word environment

Due to the fact that the report generator in Flir Tools+ is an add-in to Microsoft Word, basically all existing features you usually use when creating a Microsoft Word document template can be used when creating your report templates.

Flir Tools+ adds a number of commands that are specific to the industry of infrared imaging and reporting, and these commands can be accessed on the Flir Tools+ tab.

You use these features, along with the usual Microsoft Word features, when you create infrared report templates.

Note

Creating a report template requires skill in creating document templates in Microsoft Word. For more information about this, refer to your Microsoft Word documentation, or to the Microsoft Word online help.

When creating a custom report template, you may find it useful to select *Show/Hide ¶* on the *Home* tab in Microsoft Word.

18.1.2 Creating a custom infrared report template

You can create a custom infrared report template from a blank Microsoft Word template. The easiest way, however, is to create a report template by modifying an existing

template. By doing this, you can take advantage of the existing infrared objects already laid out on the report template page, and you will save a lot of time compared with creating an infrared report template from scratch.

You can create a report template in three different ways:

- Customize a basic report template.
- Modify an existing report template.
- Create a report template from a blank Microsoft Word template.

Customizing a basic report template

1. On the FLIR menu, select *Create a report template*. This will open the *New Template* dialog box.

2. Enter a template name and click *OK*.
3. A report template with a basic layout opens. Follow the instructions in the document to modify the report template. You can also customize the report template by adding and removing objects and by modifying the properties of the objects as described in section 18.2 *Managing objects in the report*, page 48.
4. Save the new infrared report template. Make sure that you save the template with the *.dotx file name extension.

Modifying an existing template

1. Start Microsoft Word, but make sure that all infrared reports are closed.
2. On the *File* tab, click *New*.
3. Under *Available Templates*, select *My templates*.
4. On the *IR* tab, select the infrared report template that you want to use. Under *Create New*, select *Template*.
5. Click *OK*.
6. To avoid overwriting the original template, save the template under a different file-name before making any changes. When saving it, make sure that you save it with the *.dotx file name extension.
7. Make your changes to the original template by adding and removing objects and by modifying the properties of the objects as described in section 18.2 *Managing objects in the report*, page 48.
8. Save the new infrared report template. Make sure that you save the template with the *.dotx file name extension.

Create a report template from a blank Microsoft Word template

1. Start Microsoft Word, but make sure that all infrared reports are closed.
2. On the *File* tab, click *New*.
3. Under *Available Templates*, select *My templates*.
4. On the *Personal Templates* tab, select *Blank Document*. Under *Create New*, select *Template*.
5. Click *OK*.
6. Create your report template by adding and removing objects and by modifying the properties of the objects as described in section 18.2 *Managing objects in the report*, page 48.
7. Save the new infrared report template. Make sure that you save the template with the *.dotx file name extension.

18.2 Managing objects in the report

When you create a report based on a report template, objects are automatically inserted as placeholders for infrared images, digital photos, tables, and fields on the report pages. You can also insert objects and modify their properties after you have launched the report in Microsoft Word, as described in the sections below.

When you create your own report templates, see section 18.1 *Creating a report template*, page 46, you insert objects and define their properties according to the sections below.

The following objects can appear in the report:

- IR Viewer object.
- Digital Photo object.
- IR Profile object.
- IR Histogram object.
- IR Trending object.
- Field object.
- Table object.
- Summary Table object.

Toolbars, submenus, buttons, etc., related to the objects are described in detail in section 18.4 *Software reference section*, page 65.

18.2.1 Inserting objects

18.2.1.1 IR Viewer and Digital Photo objects

IR Viewer and Digital Photo objects are placeholders that automatically load infrared and visual images when a report is created.

Inserting IR Viewer and Digital Photo objects

1. On your template page, place the cursor where you want the IR Viewer object or the Digital Photo object to appear. The placeholders will be inserted *after and below* the cursor.
2. On the Flir Tools+ tab, click

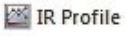
(for an IR Viewer object) or

(for a Digital Photo object). A placeholder will now appear on the page. As you are creating a template, you should not open any infrared images or photos.

18.2.1.2 IR Profile objects

When a report is created, the IR Profile object will automatically display the values of any line tools that are saved in the infrared image

Inserting IR Profile objects

1. On your template page, place the cursor where you want the IR Profile object to appear. The object will be inserted *after and below* the cursor.
2. On the Flir Tools+ tab, click 

. An empty object will now appear on the page.

Note
To edit the IR Profile settings, right-click the object on the page and select *Settings*. This will open the *Profile Settings* dialog box, see section 18.4.10.4 *Profile Settings dialog box*, page 89.

18.2.1.3 IR Histogram objects

When a report is created, the IR Histogram object will illustrate how pixels in the area tools of the image are distributed by plotting the number of pixels at each temperature level.

Inserting IR Histogram objects

1. On your template page, place the cursor where you want the IR Histogram object to appear. The object will be inserted *after and below* the cursor.
2. On the Flir Tools+ tab, click IR Histogram. An empty object will now appear on the page.

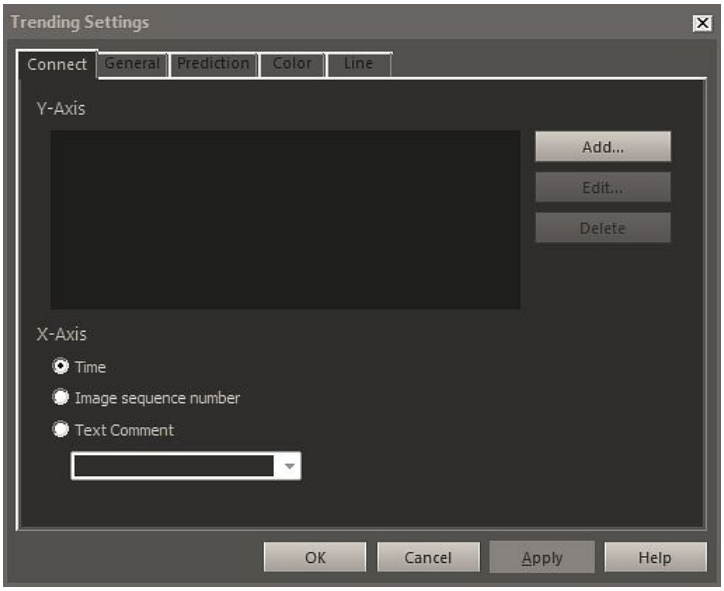
Note
To edit the IR Histogram settings, right-click the object on the page and select *Settings*. This will open the *Histogram Settings* dialog box, see section 18.4.10.5 *Histogram Settings dialog box*, page 92.

18.2.1.4 IR Trending objects

The default behavior of the IR Trending object is that it automatically displays a trend for all IR Viewer objects in the report, once the report is created. You can also manually move images to the IR Trending object using a drag-and-drop operation.

Inserting IR Trending objects

1. On your template page, place the cursor where you want the IR Trending object to appear. The object will be inserted *after and below* the cursor.
2. On the Flir Tools+ tab, click IR Trending. An empty object will now appear on the page and the *Trending Settings* dialog box will open (if the dialog box does not open, right-click the object and select *Settings*).



3. On the *Connect* tab, do the following:
    1. Specify a parameter for the Y axis. To do this click *Add* and select a label and value in the left and right panes, respectively.
    2. Specify a parameter for the X axis: *Time*, *Image sequence number* or *Text Comment*.

4. On the *General* tab, do the following:
    1. Under *General*, select options related to how the IR Trending object will be displayed.
    2. Under *Trend range*, select which images should be included in the IR Trending object.
    3. In the *Threshold* text box, enter a value that will display a horizontal baseline in the IR Trending object.
5. On the *Prediction* tab, do the following:
    1. Under *Forecast*, select the number of periods forward and backward for which the algorithm will present a probable trend.
    2. Under *Trend Regression type*, select the algorithm that you want to use.
6. On the *Color* tab, select colors for various items in the IR Trending object.
7. On the *Line* tab, select colors and line types for the lines that will be displayed in the IR Trending object.
8. Click *OK*.

Note
To edit the IR Trending settings, right-click the object on the page and select *Settings*. This will open the *Trending Settings* dialog box.

18.2.1.5 Field objects

When you create your report, the Field object will automatically display values or text linked to an infrared image.

Inserting Field objects

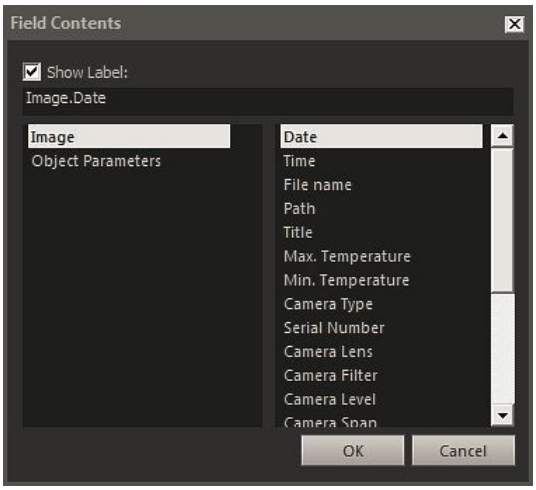
1. On your template page, place the cursor where you want the Field object to appear. The object will be inserted *after and below* the cursor.

    Note
    Field objects will not work if you insert them into a text box. Only Microsoft Word fields work in text boxes. However, Field objects work properly in Microsoft Word tables.

2. If there is more than one IR Viewer object on the page, the *Select IR Image* dialog box will be displayed. Select which IR Viewer object the Field object should be connected to and click OK.

    If there is only one IR Viewer object on the page, the Field object will automatically be connected to that IR Viewer object.

3. On the Flir Tools+ tab, click Field . The *Field Contents* dialog box will open.



4. Select the *Image* or *Object Parameters* values that you want the Field object to display.
5. Click *OK*.
6. The Field object with the contents you have selected will now appear on the page.

Note
To edit the Field contents, right-click the object on the page and select *Contents*. This will open the *Field Contents* dialog box.

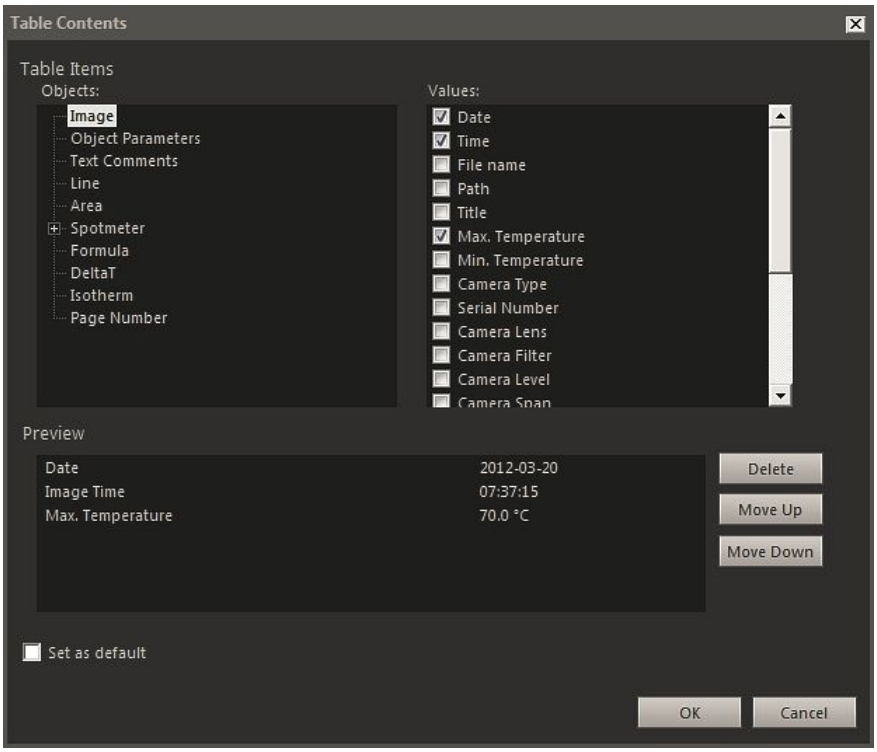
18.2.1.6 Table objects

When you create your report, the Table object will automatically display the values of any measurement tools in the infrared image.

Inserting Table objects

1. On your template page, place the cursor where you want the Table object to appear. The object will be inserted *after and below* the cursor.

2. On the Flir Tools+ tab, click Table. The *Table Contents* dialog box will be displayed.



3. For each item that you want to include in the table, do the following:
   1. In the left pane of the *Table Items* area, select an *Object*.
   2. In the right pane of the *Table Items* area, select the *Values* that you want to display in the Table object.
4. A structural preview of the table will be displayed in the *Preview* area, where you can do the following:
   - To edit the label of a table item, double-click the item and enter a new label.
   - To remove an item from the table, click the item and then click *Delete*.
   - To change the order of the table items, click an item and then click *Move Up* or *Move Down*.
5. Click *OK*.
6. The Table object with the contents you have selected will now appear on the page.

Note

- To edit the table contents, right-click the object on the page and select *Contents*. This will open the *Table Contents* dialog box.
- If a table is connected to an infrared image and you delete either the table or the image, you will not be able to recreate the connection again.

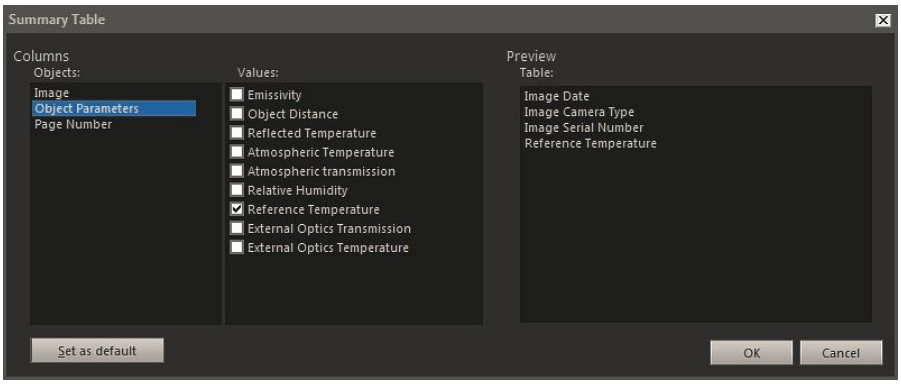
18.2.1.7 Summary Table objects

When you create your report, the Summary Table object will automatically display values of the items you have chosen to include in the table.

Inserting Summary Table objects

1. On your template page, place the cursor where you want the Summary Table object to appear. The object will be inserted *after and below* the cursor.

2. On the Flir Tools+ tab, click Summary Table. The *Summary Table* dialog box will open.



3. For each item that you want to include in the Summary Table, do the following:
   1. In the left pane of the *Columns* area, select an object.
   2. In the right pane of the *Columns* area, select the value that you want to display in the Table object.
4. A structural preview of the Summary Table will be displayed in the *Preview* area.

   To edit the label of an item, double-click the item in the *Preview* area and enter a new label.
5. Click *OK*.
6. The Summary Table object with the contents you have selected will now appear on the page.

Note
To edit the Summary Table contents, right-click the object on the page and select *Contents*. This will open the *Summary Table* dialog box.

18.2.2 Connecting objects

This description assumes that you have one IR Profile object and at least one IR Viewer object on your template page.

The objects you connect must be on the same page when you connect them. If the document is repaginated and one of the objects falls on a different page, the connection will, however, still be maintained.

Connecting objects

1. Select the IR Profile object on the page.
2. On the Flir Tools+ tab, click Connect. The *Select IR Image* dialog box will open.

3. Select the IR Viewer object that you want to connect the IR Profile object to.
4. Click *OK*.

18.2.3 Resizing objects

Resizing infrared objects

1. Select an IR Viewer, Digital Photo, IR Profile, IR Histogram, or IR Trending object on your template page.
2. To change the size of the object, drag one of the handles.

Resizing Table and Summary Table objects

1. Select a Table or Summary Table object on your template page.
2. On the Microsoft Word contextual tab *Table Tools*, select the *Layout* tab and use the controls to change the size of the table.

18.2.4 Deleting objects

Deleting infrared objects

1. Select an IR Viewer, Digital Photo, IR Profile, IR Histogram, or IR Trending object on your template page.
2. To delete the object, click

.

Deleting Table and Summary Table objects

1. Select a Table or Summary Table object on your template page.
2. On the Microsoft Word contextual tab *Table Tools*, select the *Layout* tab. Click the *Delete* button and select *Delete Table*.

Deleting Field objects

Note
This procedure applies to Flir Tools+ Field objects only (not Microsoft Word fields).

1. Place the cursor just to the left of the Field object on your template page and click once. This will select the whole Field object.
2. Press DELETE on your keyboard twice.

18.2.5 IR Viewer measurement tools

An infrared image contains valid temperature information that may be output by overlaying different kinds of tools, such as spotmeters, profiles, or areas.

The tools are accessed from the IR Viewer toolbar, which is displayed when you click the IR Viewer object.

Click to display the selection tool, which works similarly to selection tools in word-processing and desktop-publishing programs. You use the selection tool to select measurement tools.

Click to display a spotmeter with an attached flag that you can use to identify temperature values by moving it over the infrared image. If you click the image, the flying spotmeter tool will create a fixed spotmeter on the image. To stop the flying spotmeter mode, press ESC.

Click to create fixed spotmeters on infrared images. The measurement result can then be displayed in a Table object.

Click to create areas on infrared images. The measurement result can then be displayed in a Table object.

Click to create ellipsoidal areas on infrared images. The measurement result can then be displayed in a Table object.

Click to create polygon areas on infrared images. The measurement result can then be displayed in a Table object.

Click to create a line on infrared images. The measurement result can then be displayed in an IR Profile object.

Click to create a bent line on infrared images. The measurement result can then be displayed in an IR Profile object.

Click to calculate the difference between two temperatures—for example, two spotmeters, or a spotmeter and the maximum temperature in the image. The result from the calculation will be displayed both as a ToolTip and as a result in the result table. Using this toolbar button requires you to have laid out at least one measurement function on your image.

Click to create a marker that you can move anywhere in an image and point to an area of interest.

Click to display a menu where you can do one of the following:

- Insert an isotherm above a temperature level. This assigns a color to all temperatures above a certain temperature level in an image with one preset color.
- Insert an isotherm below a temperature level. This assigns a color to all temperatures below a certain temperature level in an image with one preset color.
- Set an isotherm color that is displayed when the camera detects an area where there may be a risk of humidity in the building structure (a humidity alarm).
- Set an isotherm color that is displayed when the camera detects what may be an insulation deficiency in a wall (an insulation alarm).
- Insert an isotherm between two temperature levels. This assigns a color to all temperatures between two temperature levels in an image with one preset color.

For more information about isotherm settings, see section 18.4.10.2.2 *Isotherms tab*, page 79.

Click to draw a rectangle around the area that you want to zoom in on. When you are in zoom mode, a thumbnail image will appear in the top right corner, indicating the location of the area you have zoomed in to. You can move the area by clicking and holding down the left mouse button, then moving the mouse in any direction. To leave the zoom mode, either select *1*× on the *Zoom* menu or press the space bar on the keyboard.

Click to open the *Image Fusion* dialog box. For more information on image fusion, see section 18.2.7 *Image fusion*, page 61.

Click to turn on/off grid lines in the IR Viewer object. For more information about the grid tool, see section 18.2.5.2 *Using the Grid tool*, page 56.

18.2.5.1 Managing the measurement tools

Once you have added measurement tools such as spotmeters, areas, and markers to an IR Viewer object, you can apply actions such as moving, cloning, and deleting to them.

Selecting a measurement tool in the image

1. Do one of the following:
   - To select one tool, click the tool.
   - To select successive tools in one direction, press TAB.
   - To select successive tools in the other direction, press and hold SHIFT and then press TAB.
   - To select several tools, SHIFT-click the tools.
   - To select all tools, select the IR Viewer object and press A.
   - To select one or several tools, click and draw a rectangle around the tools that you want to select.

Moving a measurement tool

1. Do one of the following:
   - To move the tool, press the arrow keys.
   - To move the tool, use the mouse.

Cloning measurement tools

1. To clone a tool, press and hold CTRL when you move the tool. This will create a clone of the tool.

Deleting measurement tools

1. To delete a tool, do one of the following:
   - Select the tool and press DELETE.
   - Select the tool, right-click and select *Delete*.

18.2.5.2 Using the Grid tool

Using the Grid tool, and knowing the field of view of the lens and the distance to the object of interest, you can lay out a grid on an IR Viewer object, where each square of the grid represents a known area.

You can also lay out a line in the IR Viewer object and specify the length of the line.

Note

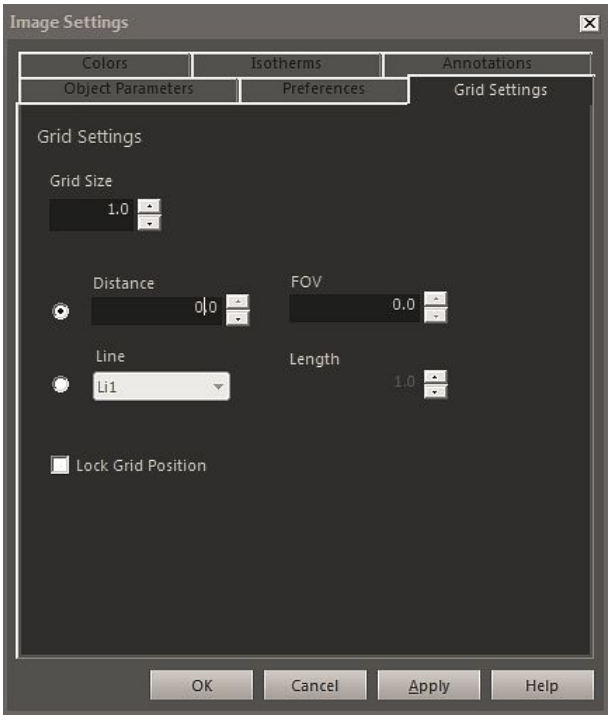
- For accurate calculations, it is very important that you record the correct distance to the object at the time of inspection. You can do this in the camera or on paper.
- For accurate calculations, it is also very important that the image is taken at a 90° angle to the object.

Using the Grid tool

1. Select an IR Viewer object.
2. Click to turn on the grid lines.

   Click the IR Viewer object outside the grid (for example near the temperature scale) to display the IR Viewer object toolbar.
3. To use a line as reference, click on the IR Viewer object toolbar and lay out a line in the image.
4. Right-click the IR Viewer object and select *Settings* from the shortcut menu.

5. The *Image Settings* dialog box will open. Select the *Grid Settings* tab.



6. Set the grid size to a value of your choice.
7. Click one of the option buttons and do one of the following:
   - Enter values for distance and and FOV (field of view).
   - Select a line from the drop-down list and specify the length of the line.
8. Click *OK*.
9. Select on the IR Viewer object toolbar and move the grid to the desired position. For example, you may want to align the grid with certain structures in the image, areas of interest, etc.
10. To lock the grid relative to the image, check the box *Lock Grid Position* on the *Grid Settings* tab and click *OK*.

18.2.6 Formulas

18.2.6.1 General

Flir Tools+ allows you to carry out advanced calculations on various items in the infrared image. A formula can contain all common mathematical operators and functions (+, –, ×, ÷, etc). Also, numerical constants such as π can be used.

Most importantly, references to measurement results, other formulas, and other numerical data can be inserted into formulas.

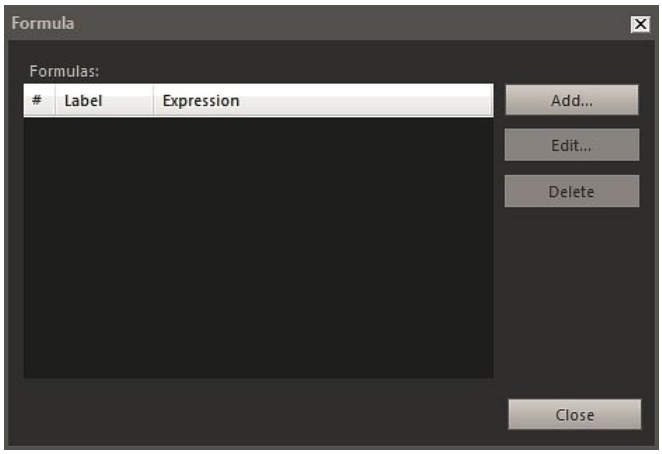
Note
A formula can only operate on a single infrared image: it cannot calculate, for example, differences between two infrared images.

18.2.6.2 Creating a simple formula

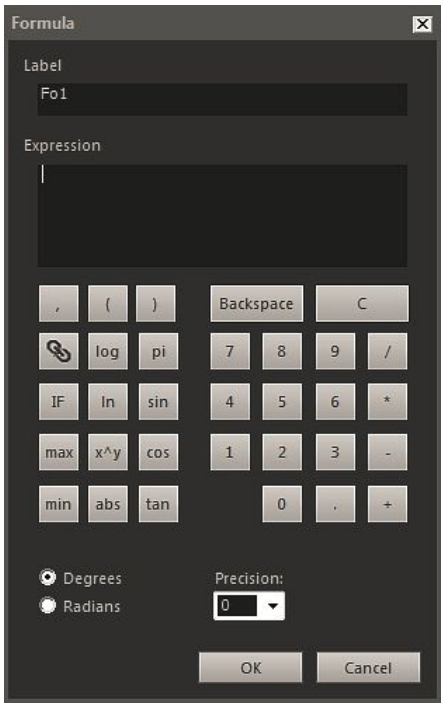
Creating a formula that calculates the difference between two spots

1. In your document, insert an IR Viewer object.
2. Lay out two spots in the image.

3. Right-click the IR Viewer object and select *Formulas*. This will display the *Formula* dialog box.



4. Click *Add* to display a dialog box in which you define your new formula.



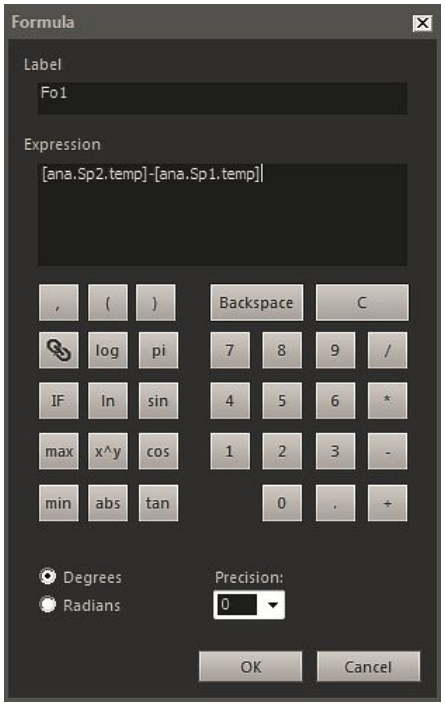
5. Do the following:

   1. Click to display a dialog box.
   2. Click Sp2 in the left list box.
   3. Click *OK* to leave the dialog box.

6. Click the minus button to add a subtraction mathematical operator.
7. Do the following:

   1. Click to display a dialog box.
   2. Click Sp1 in the left list box.
   3. Click *OK* to leave the dialog box.

8. The *Formula* dialog box will now display your formula using Flir Systems syntax:



9. Click *OK* to leave the *Formula* dialog box.
10. Click *Close*.
11. Place the cursor below the IR Viewer object and insert a Table object. The *Table Contents* dialog box will open.
12. Do the following:
    1. In the left pane of the *Table Items* area, double-click *Formula* and select the formula you have created. Formulas are indicated by the *Fo* prefix.
    2. In the right pane of the *Table Items* area, check the *Values* box.
       A structural preview of the Table will be displayed in the *Preview* area.
    3. Click *OK*.
13. The formula result is now displayed in your Table object.

18.2.6.3 Creating a conditional formula

For some applications, you may, for example, want to display the result of a calculation in a green font color if the result is lower than a critical value, and in a red font color if the result is higher than the critical value.

You do this by creating a conditional formula using the *IF* statement.

Creating a conditional formula using the IF statement

1. Repeat Steps 1.–10. in the procedure in section 18.2.6.2 *Creating a simple formula*, page 57.
2. Right-click the IR Viewer object and select *Formulas*.
3. Do the following:
    1. Click *Add* to display a dialog box in which you define your new formula.
    2. Click the *IF* button to display a new dialog box.

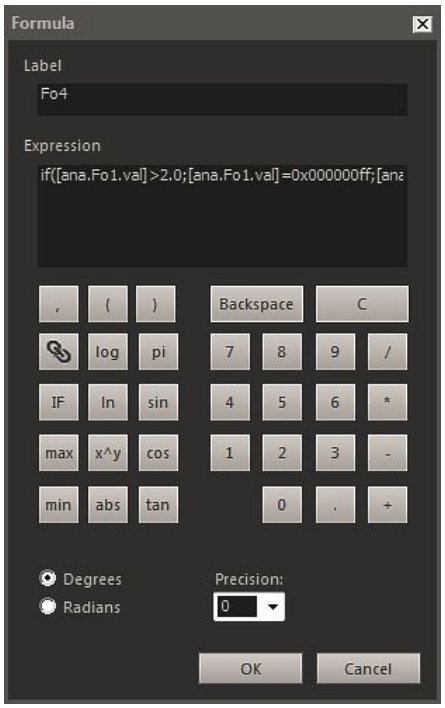
4. You will now set up a conditional formula that displays the result from the Fo1 formula in red if the value is higher than 2.0 degrees, and in green if the value is lower than 2.0 degrees.

   Do the following:

   1. Click to the right of the *Logical test* text box, select Fo1 from the left drop-down list, and click *OK*.
   2. In the *Logical test* text box, enter *>2.0*. This will be your condition.
   3. Click to the right of the *Value if true* text box, select Fo1 from the left drop-down list, and click *OK*.
   4. Click *Default Color* to the right of the *Value if true* text box and select the color red.
   5. Click to the right of the *Value if false* text box, select Fo1 from the left drop-down list, and click *OK*.
   6. Click *Default Color* to the right of the *Value if false* text box and select the color green.

   7. Click *OK* to leave the dialog box.

5. You will now see the complete conditional formula in the Formula dialog box. The two 10-digit code strings after the equals sign represent the colors.



6. Click *OK* to leave the *Formula* dialog box.
7. Click *Close*.
8. Place the cursor below the IR Viewer object. On the Flir Tools+ tab, click Field . The *Field Contents* dialog box will open.
9. Do the following:
   1. In the left pane, click the conditional formula you have created.
   2. Click *OK*.

   A Field object will now be inserted below your image, and the result of the Fo1 formula will be displayed in red or green, depending on the measured values of the two spotmeters.

Note
These types of conditional formulas can be connected to the following objects:

- Field objects.
- Table objects.
- Summary Table objects.

18.2.7 Image fusion

18.2.7.1 General

Flir Tools+ allows you to fuse an infrared image with a visual image. Fusing images can make it easier to identify the exact position of temperature anomalies.

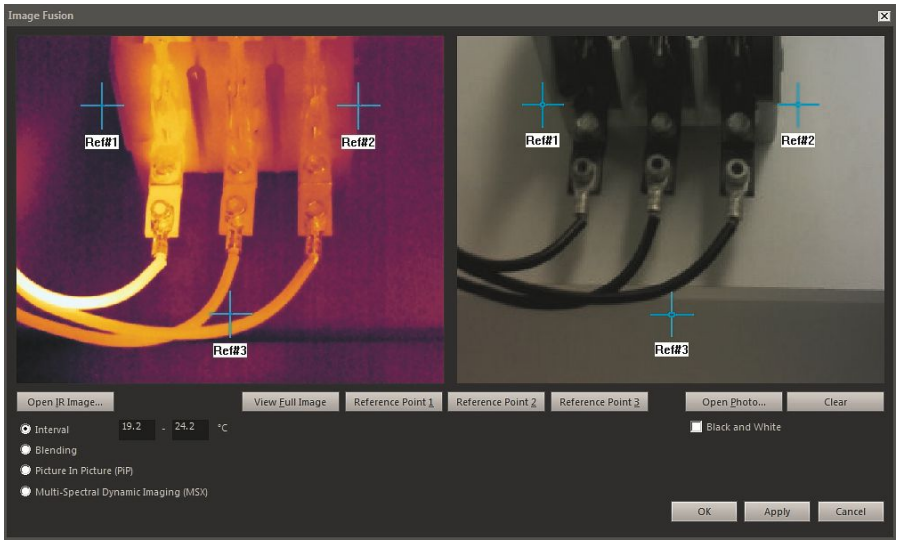
18.2.7.2 Image fusing procedure

Fusing an infrared image with a visual image

1. Insert an IR Viewer object.

2. Open the *Image Fusion* dialog box by doing one of the following:

   - In the IR Viewer object toolbar, click .
   - Right-click the IR Viewer object and select *Image Fusion* from the shortcut menu.



3. Click *Open IR Image* and select an infrared image.
4. Click *Open Photo* and select the corresponding digital photo.
5. In the infrared image, define the positions of interest by moving the three reference crosshairs to these positions.
6. In the digital photo, move the three reference crosshairs to the corresponding positions.
7. Select type of image fusion technology:

   - Select *Interval* to use one temperature interval for the infrared image and to use the digital photo for lower and higher temperatures. Enter the desired temperature values in the corresponding text boxes. You can adjust the temperature levels by dragging the sliders in the IR Viewer object, once you have closed the dialog box.
   - Select *Blending* to display a blended image that uses a mix of infrared pixels and digital photo pixels. You can adjust the mixing levels by dragging the sliders in the IR Viewer object, once you have closed the dialog box.
   - Select *Picture in Picture (PiP)* to display a portion of a digital photo within an infrared image. In the IR Viewer object, you can then move and resize the PiP to anywhere and any size in the photo, to show the level of detail that you want in your report.
   - Select *Multi-Spectral Dynamic Imaging (MSX)* to enhance the contrast in the infrared image. This MSX fusion technology embosses digital camera details onto the infrared image, enabling a sharper-looking infrared image and quicker target orientation.

8. To display the fused image, click *OK*.
9. In the IR Viewer object, you can adjust the exact position of the digital photo in the fused image by doing one or more of the following:

   - To move the digital photo up/down or left/right in 1 pixel increments, use the arrow keys on your keyboard.
   - To rotate the digital photo clockwise/counter-clockwise in 1° increments, use the Page Up and Page Down keys on your keyboard.

10. In the IR Viewer object, you can control Image Fusion with the slider at the bottom of the IR Viewer object.

    Slider to control Image Fusion with the Interval setting:

    Slider to control Image Fusion with the Blending setting:

    Slider to control Image Fusion with the Multi-Spectral Dynamic Imaging (MSX) setting:

    Drag the slider left or right to fuse the infrared image with the digital photo. You can also use one of the following shortcuts:

    - To go to the full infrared image or to the full digital photo, double-click the corresponding icon at the left or right end of the gauge.
    - To center the slider on the gauge, right-click the gauge.
    - To move the slider to a specific position on the gauge, double-click the gauge at that position.
    - To move the slider in small increments to the left or to the right, click the gauge to the left or to the right of the slider.

For more information about Image Fusion, see sections see section 18.4.10.7 *Image Fusion dialog box*, page 98.

18.3 Document properties

18.3.1 General

When creating an infrared report, Flir Tools+ extracts the Microsoft Word document properties for the report template and inserts these properties into corresponding Microsoft Word fields in the final report.

You can use these document properties to automate several time-consuming tasks when creating a report. For example, you may want Flir Tools+ to automatically add information such as the name, address, and e-mail address of the inspection site, the model name of the camera that you are using, and your e-mail address.

18.3.2 Types of document properties

There are two different types of document properties:

- Summary document properties.
- Custom document properties.

For the former, you can only change the values, but for the latter you can change both the labels and the values.

18.3.3 Creating and editing Microsoft Word document properties

Creating and editing document properties

1. Start Microsoft Word and open one of your infrared report templates (*.dotx). You can locate the report templates that are shipped with Flir Tools+ by typing the following path:

   C:\Documents and Settings\[Your user name]\Application Data\Microsoft\Templates\IR
2. On the *File* tab, click *Info*.
3. From the *Properties* download menu, select *Advanced Properties*.
4. On the *Summary* tab, enter your information in the appropriate text boxes.
5. Click the *Custom* tab.

6. To add a custom property, type a name in the *Name* box. To make your custom properties easy to find, you can type an underscore (_) as the first character in the name of the property.
7. Use the *Type* box to specify the type of property.
8. To specify the value of the property, type it in the *Value* box.
9. Click *Add* to add the custom property to the list of properties, and then click *OK*.
10. Save the infrared report template using a different filename but with the same filename extension (*.dotx). You have now added summary and custom properties to your renamed infrared report template.

Note

- If you want to change the name of a custom document property, due to how the *Custom* tab of the *Properties* dialog box in Microsoft Word works, the only way to do this is to delete it and then recreate it. If you want to move a document property up or down, the whole list has to be recreated.
- A Microsoft Word field is not the same as a field inserted by clicking on the Field button on the Flir Tools+ tab.
- You may find that a Flir Systems property has been added to your document automatically. Do not remove this property. Flir Tools+ uses it to distinguish between infrared documents and other documents.

18.3.4 Changing the prefix for a report property

18.3.4.1 General

When a report has been generated, a *Report properties* dialog box will be displayed. In this dialog box you can enter customer information and information about the inspection. The information you enter in this dialog box will then populate the corresponding placeholders in the report.

The report properties show up dependent on the fact that they start with an underscore (_). However, if you have created your own custom templates, you may have created report properties with a different prefix, e.g., using a percentage sign (%), a dollar sign ($), a hash sign (#), or the whole or part of your company name (e.g., “ACME”). To have these properties show up when you have generated the report, you need to update the property *FLIR_ReportPropertyPrefix*.

18.3.4.2 Procedure

Note
This procedure assumes that you have created your own set of custom report properties, using a prefix other than the underscore (_).

Follow this procedure:

1. Start Microsoft Word and open one of your infrared report templates (*.dotx). You can locate the report templates that are shipped with Flir Tools+ by typing the following path:

   C:\Documents and Settings\[Your user name]\Application Data\Microsoft\Templates\IR
2. On the *File* tab, click *Info*.
3. From the *Properties* download menu, select *Advanced Properties*.
4. On the *Summary* tab, enter your information in the appropriate text boxes.
5. Click the *Custom* tab.
6. Under *Properties*, select *FLIR_ReportPropertyPrefix*.
7. Under *Value*, type the prefix that you want to use for your custom report properties.
8. Save the report template as a *.dotx file.

18.3.5 Creating a Microsoft Word field and linking the field to a document property

Note
This description assumes that you have created summary and custom properties according to section 18.3.3 *Creating and editing Microsoft Word document properties*, page 63.

Creating and linking a Microsoft Word field

1. In your infrared report or report template, put the cursor where you want to insert the field.
2. On the *Insert* tab, click *Quick Parts*, and select *Field*.
3. In the *Field names* box, select *DocProperty*.
4. Select a property in the *Property* box.
5. Click *OK*.

18.4 Software reference section

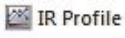
This section describes in detail all menus, buttons, dialog boxes, etc., related to Flir Tools+.

18.4.1 Flir Tools+ tab

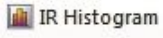
After installation of Flir Tools+, the Flir Tools+ tab appears to the right of the standard tabs in the Ribbon of your Microsoft Word documents.

Click to insert an IR Viewer object for infrared images and sequence files. An infrared image or a sequence file contains valid temperature information that may be output by overlaying different kinds of measurement tools, such as spotmeters, profiles, and areas.

Click to insert a Digital Photo object. This photo may have been taken with a stand-alone digital camera, or with the digital visual camera featured on some Flir Systems infrared cameras. Only use this method to insert a photo when you design a report template. In all other situations, insert photos by clicking *Picture* on the *Insert* tab.

Click 

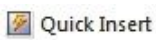
to insert an IR Profile object. An IR Profile object contains a graph showing pixel values along a line in an infrared image.

Click 

to insert an IR Histogram object. An IR Histogram object contains a graph illustrating how pixels in the image are distributed by plotting the number of pixels at each temperature level.

Click

to insert an IR Trending object. A trending object is a graphical representation of measurement values or text comment values on the Y axis against infrared report pages or infrared images on the X axis, sorted by time, page number, or text comment values. It can also display probable trends, according to different algorithms.

Click 

to display the *QuickInsert* dialog box, see section 18.4.10.1 *QuickInsert dialog box*, page 76, where you can create a report by selecting a predefined page layout or modifying an existing page layout.

Click

to connect infrared objects to each other, for example an IR Profile object to an IR Viewer object.

Click an infrared object and then click

to remove the object from your report.

Click Field to insert a Field object into your current document. A Field object can be linked to values or text in your infrared image.

Click Table to insert a Table object into your current document. A Table object displays the results of the measurement tools laid out in the infrared image, as well as other information that is related to the infrared image.

Click Summary Table to insert an Summary Table object. A Summary Table object lists infrared data of your choice from all infrared images in the report, one row per image.

Click Delete Page to delete the current page.

Click Duplicate Page to duplicate the current page and insert the duplicate page after the current page.

Click *Report properties* to display a dialog box where you can enter customer information and information about the inspection. For more information about this, see section 18.3.4 *Changing the prefix for a report property*, page 64.

Click FLIR to display the Flir submenu, see section 18.4.1.1 *Flir submenu*, page 66.

18.4.1.1 Flir submenu

The Flir submenu is displayed when you click FLIR on the Flir Tools+ tab:

Create a report template: Click to open a default template that you can use as a basis for further customizations.

Select Units: Click to display a dialog box, where you can set temperature and distance units.

Apply IR Viewer settings globally: This command is only enabled when an IR Viewer object has been selected. Click to apply the settings of the selected IR Viewer object globally.

Selected language: Click to display a dialog box where you can set language.

About: Click to display a dialog box with information about the program version.

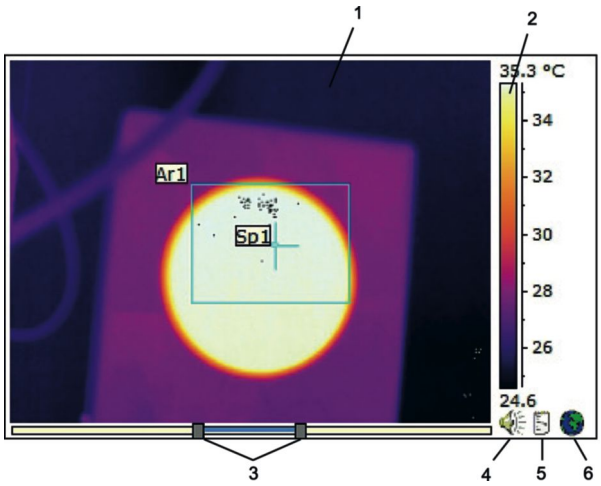
18.4.2 IR Viewer object

18.4.2.1 General

An IR Viewer object is a placeholder for infrared images and sequence files. An infrared image contains valid temperature information that may be output by overlaying different kinds of measurement tools, such as spotmeters, profiles, and areas.

The appearance of the IR Viewer object depends on whether an infrared image or a sequence file is selected.

18.4.2.1.1 IR Viewer object with infrared image



The IR Viewer object with an infrared image contains the following information (numbers refer to the figure above):

1. Infrared image.
2. Temperature scale.
3. Sliders to adjust the level and span. To auto-adjust an image for the best image brightness and contrast, right-click one of the sliders. To move both sliders together, press and hold SHIFT and move one of the sliders.
4. Indicates that the image file has a voice comment. Click to listen to the voice comment.
5. Indicates that the image file has a text comment. Click to display the text comment.
6. Indicates that the image file has embedded GPS data. Click the globe to display the position on a map.

If Image Fusion is applied, an additional slider is displayed at the bottom of the IR Viewer object. The appearance of the slider depends on the type of Image Fusion, as illustrated in the figures below.

Slider to control Image Fusion with the Interval setting:

Slider to control Image Fusion with the Blending setting:

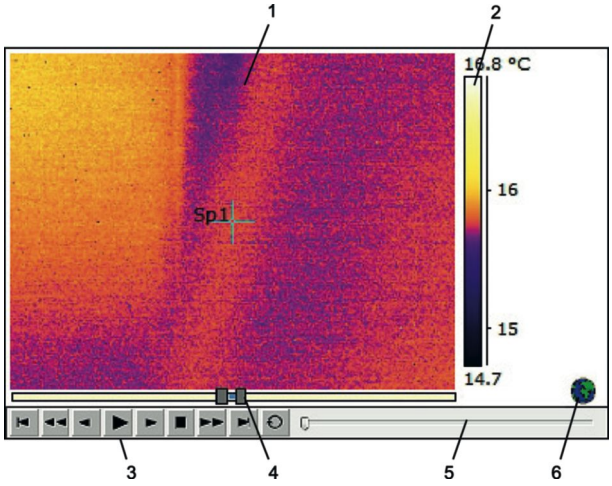
Slider to control Image Fusion with the Multi-Spectral Dynamic Imaging (MSX) setting:

To control Image Fusion, drag the slider left or right to fuse an infrared image with a digital photo. You can also use one of the following shortcuts:

- To go to the full infrared image or to the full digital photo, double-click the corresponding icon at the left or right end of the gauge.
- To center the slider on the gauge, right-click the gauge.
- To move the slider to a specific position on the gauge, double-click the gauge at that position.
- To move the slider in small increments to the left or to the right, click the gauge to the left or to the right of the slider.

For more information about Image Fusion, see sections 18.2.7 *Image fusion*, page 61 and 18.4.10.7 *Image Fusion dialog box*, page 98.

18.4.2.1.2 IR Viewer object with a sequence file

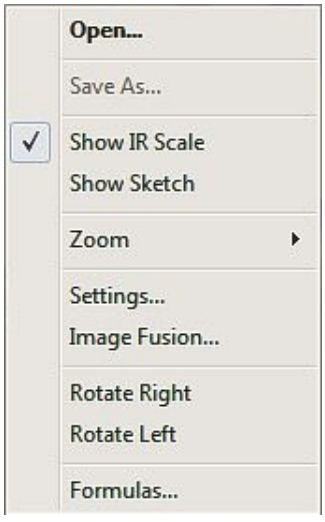


The IR Viewer object with a sequence file contains the following information (numbers refer to the figure above):

1. Infrared sequence.
2. Temperature scale.
3. Control buttons to play back the sequence file.
4. Sliders to adjust scale limits.
5. Progress indicator.
6. Indicates that the image file has embedded GPS data. Click the globe to display the position on a map.

18.4.2.2 IR Viewer shortcut menu

The IR Viewer object shortcut menu is displayed when right-clicking an IR Viewer object.



Open: Click to open an image in the IR Viewer object placeholder, or to change the current image to a new image.

Save As: Click to save the currently displayed image to your hard disk drive.

Show IR Scale: Click to show/hide the infrared scale at the far right in the infrared image.

Show Sketch: Click to show/hide a freehand sketch associated with the image. (Not all cameras support the creation of freehand sketches. This option will be visible only if the images contain a freehand sketch.) For some old images, if there are any markers, these

will be shown on the *Annotations* tab > *Sketch*, see section 18.4.10.2.3 *Annotations tab*, page 83.

Zoom: Click 1×, 2×, 4×, or 8× on the *Zoom* menu to zoom in on the currently displayed image.

Settings: Click to open the *Image Settings* dialog box, see section 18.4.10.2 *Image Settings dialog box*, page 77.

Image Fusion: Click to open the *Image Fusion* dialog box, see section 18.4.10.7 *Image Fusion dialog box*, page 98.

Rotate Right: Click to rotate the image 90° to the right.

Rotate Left: Click to rotate the image 90° to the left.

Formulas: Click to open the *Formula* dialog box, see section 18.4.10.8 *Formula dialog box*, page 99.

18.4.2.3 IR Viewer toolbar

The IR Viewer object toolbar is displayed when an IR Viewer object is selected.

Note
When the grid is turned on, you need to click the IR Viewer object outside the grid (e.g., near the temperature scale) to display the IR Viewer object toolbar.

Click to display the selection tool, which works similarly to selection tools in word-processing and desktop-publishing programs. You use the selection tool to select measurement tools.

Click to display a spotmeter with an attached flag that you can use to identify temperature values by moving it over the infrared image. If you click the image, the flying spotmeter tool will create a fixed spotmeter on the image. To stop the flying spotmeter mode, press ESC.

Click to create fixed spotmeters on infrared images. The measurement result can then be displayed in a Table object.

Click to create areas on infrared images. The measurement result can then be displayed in a Table object.

Click to create ellipsoidal areas on infrared images. The measurement result can then be displayed in a Table object.

Click to create polygon areas on infrared images. The measurement result can then be displayed in a Table object.

Click to create a line on infrared images. The measurement result can then be displayed in an IR Profile object.

Click to create a bent line on infrared images. The measurement result can then be displayed in an IR Profile object.

Click to calculate the difference between two temperatures—for example, two spotmeters, or a spotmeter and the maximum temperature in the image. The result from the calculation will be displayed both as a ToolTip, and as a result in the result table. Using this toolbar button requires that you have laid out at least one measurement function on your image.

Click to create a marker that you can move anywhere in an image and point to an area of interest.

Click to display a menu where you can do one of the following:

- Insert an isotherm above a temperature level. This assigns a color to all temperatures above a certain temperature level in an image with one preset color.
- Insert an isotherm below a temperature level. This assigns a color to all temperatures below a certain temperature level in an image with one preset color.
- Set an isotherm color that is displayed when the camera detects an area where there may be a risk of humidity in the building structure (a humidity alarm).
- Set an isotherm color that is displayed when the camera detects what may be an insulation deficiency in a wall (an insulation alarm).
- Insert an isotherm between two temperature levels. This assigns a color to all temperatures between two temperature levels in an image with one preset color.

Click to draw a rectangle around the area that you want to zoom in on. When you are in zoom mode, a thumbnail image will appear in the top right corner, indicating the location of the area you have zoomed in to. You can move the area by clicking and holding down the left mouse button, then moving the mouse in any direction. To leave the zoom mode, either select *1×* on the *Zoom* menu, or press the space bar on the keyboard.

Click to open the *Image Fusion* dialog box, see section 18.4.10.7 *Image Fusion dialog box*, page 98.

Click to turn on/off the grid lines in the graph of the IR Viewer object.

18.4.2.4 IR Viewer tools shortcut menu

The appearance of the IR Viewer tools shortcut menu depends on which tool you right-click.

Cursor: Applicable for lines only. Click to create a cursor that you can move along the line.

Delete: Click to remove the currently selected tool from the infrared image.

Cold Spot: Applicable for all tools except the spotmeter, difference calculation, and marker. Click to create a spotmeter at the coldest location in the area.

Hot Spot: Applicable for all tools except the spotmeter, delta, and marker. Click to create a spotmeter at the hottest location in the area.

Formulas: Click to open the *Formula* dialog box, see section 18.4.10.8 *Formula dialog box*, page 99.

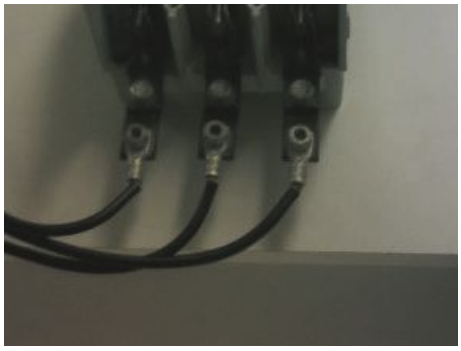
Settings: Click to open the *Measurement Settings* dialog box, see section 18.4.10.3 *Measurement Settings dialog box*, page 87.

Image: This menu is identical to the IR Viewer shortcut menu, see section 18.4.2.2 *IR Viewer shortcut menu*, page 68.

18.4.3 Digital Photo object

18.4.3.1 General

The Digital Photo object is a placeholder for photos. This photo may be taken with a stand-alone digital camera, or with the digital visual camera featured on some Flir Systems infrared cameras.



18.4.3.2 Digital Photo object shortcut menu

The Digital Photo object shortcut menu is displayed when right-clicking a Digital Photo object.

Open: Click to open an image in the Digital Photo object placeholder, or to change the current image to a new image.

Show Sketch: Click to show/hide a freehand sketch associated with the image. (Not all cameras support the creation of freehand sketches.) For old images, if there are any markers, these will be shown/hidden by this command.

18.4.4 IR Profile object

18.4.4.1 General

An IR Profile object contains a graph showing pixel values along a line in an infrared image.

18.4.4.2 IR Profile object shortcut menu

The IR Profile object shortcut menu is displayed when right-clicking an IR Profile object.

Grid Lines: Click to display a grid of horizontal lines in the IR Profile object.

Legend: Click to display a legend below the IR Profile object.

Show Only Visible Profile Lines in Legend: If two or more lines are laid out in the infrared image, clicking *Show Only Visible Profile Lines in Legend* will remove any cleared line results from the legend below the IR Profile object.

3D View: Click to create a three-dimensional rendering of the graph of the IR Profile object.

Swap X & Y Axes: Click to swap the X and Y axes of the IR Profile object.

Settings: Click to open the *Profile Settings* dialog box, see section 18.4.10.4 *Profile Settings dialog box*, page 89.

18.4.4.3 IR Profile toolbar

The IR Profile object toolbar is displayed when an IR Profile object is selected.

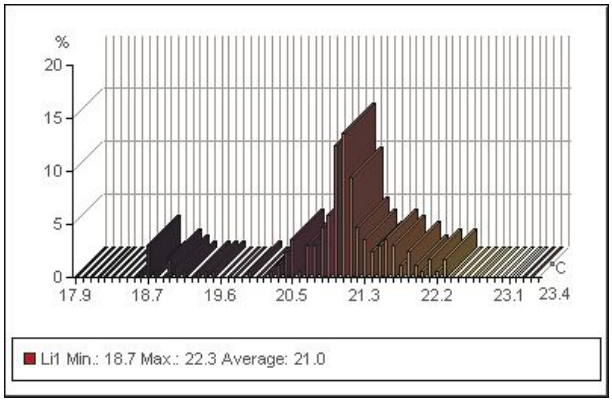
Click to create a three-dimensional rendering of the graph of the IR Profile object.

Click to turn on/off the grid lines in the graph of the IR Profile object.

18.4.5 IR Histogram object

18.4.5.1 General

An IR Histogram object contains a graph illustrating how pixels in the image are distributed by plotting the number of pixels at each temperature level.



18.4.5.2 IR Histogram object shortcut menu

The IR Histogram object shortcut menu is displayed when right-clicking an IR Histogram object.

Grid Lines: Click to display a grid of horizontal lines in the IR Histogram object.

Legend: Click to display a legend below the IR Histogram object.

3D View: Click to create a three-dimensional rendering of the graph of the IR Histogram object.

Swap X & Y Axes: Click to swap the X and Y axes of the IR Histogram object.

Settings: Click to open the *Histogram Settings* dialog box, see section 18.4.10.5 *Histogram Settings dialog box*, page 92.

18.4.5.3 IR Histogram toolbar

The IR Histogram object toolbar is displayed when an IR Histogram object is selected.

Click to create a three-dimensional rendering of the graph of the IR Histogram object.

Click to turn on/turn off colors in the graph of the IR Histogram object.

Click to turn on/turn off the grid lines in the graph of the IR Histogram object.

Click to use a *band* threshold in the IR Histogram object. A *band* threshold shows the percentage of pixels below a lower temperature, between this lower temperature and a higher temperature, and above that higher temperature. The percentages are displayed in the threshold legend below the IR Histogram object.

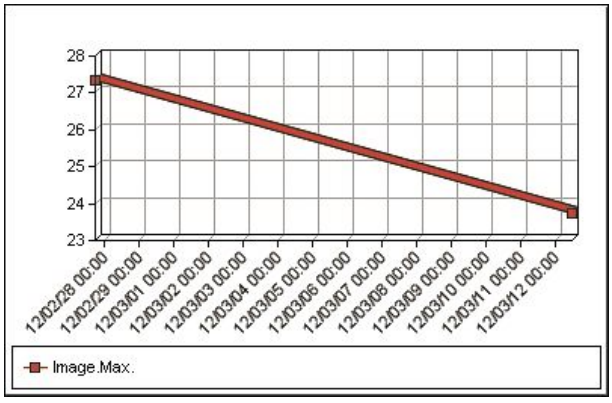
Click to use a *step* threshold in the IR Histogram object. A *step* threshold shows the percentage of pixels below and above a specific temperature. The percentages are displayed in the IR Histogram object legend below the IR Histogram object.

If you have created several lines and/or areas in the IR Viewer object, select the line or area display from the drop-down list.

18.4.6 IR Trending object

18.4.6.1 General

An IR Trending object is a graphical representation of measurement values or text comment values on the Y axis against infrared report pages or infrared images on the X axis, sorted by time, page number, or text comment values. An IR Trending object can also display probable trends, according to different algorithms.



18.4.6.2 IR Trending object shortcut menu

The IR Trending object shortcut menu is displayed when right-clicking an IR Trending object.

Grid Lines: Click to display a grid of horizontal lines in the IR Trending object.

Legend: Click to display a legend below the IR Trending object.

Show Only Visible Plot Lines in Legend: Click to display trend lines in the legend that you have cleared in the *Trending Settings* dialog box, see section 18.4.10.6 *Trending Settings dialog box*, page 94.

3D View: Click to create a three-dimensional rendering of the graph of the IR Trending object.

Swap X & Y Axes: Click to swap the X and Y axes of the IR Trending object.

Refresh: Click to update the trending graph.

Settings: Click to open the *Trending Settings* dialog box, see section 18.4.10.6 *Trending Settings dialog box*, page 94.

18.4.6.3 IR Trending toolbar

The IR Trending object toolbar is displayed when an IR Trending object is selected.

Click to create a three-dimensional rendering of the graph of the IR Trending object.

Click to turn on/off the grid lines in the graph of the IR Trending object.

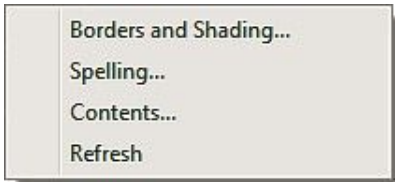
18.4.7 Field object

18.4.7.1 General

A Field object can be linked to values or to text in your infrared image.

18.4.7.2 Field object shortcut menu

The Field object shortcut menu is displayed when right-clicking a Field object.



Borders and Shading: Click to open the standard Microsoft Word feature.

Spelling: Click to open the standard Microsoft Word feature.

Contents: Click to open the *Field Contents* dialog box, see section 18.2.1.5 *Field objects*, page 50.

Refresh: Click to refresh the Field object contents. You usually only have to do this if you have changed the contents manually.

18.4.8 Table object

18.4.8.1 General

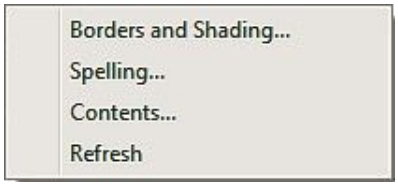
A Table object displays the results of the measurement tools laid out in the infrared image, as well as other information that is related to the infrared image.

You can edit the text in the Table object, once the report is created. However, these changes will be deleted when you right-click the Table object and select *Refresh*.

Date	2012-03-20
Image Time	07:37:15
Max. Temperature	70.0 °C

18.4.8.2 Table object shortcut menu

The Table object shortcut menu is displayed when right-clicking a Table object.



Borders and Shading: Click to open the standard Microsoft Word feature.

Spelling: Click to open the standard Microsoft Word feature.

Contents: Click to open the *Table Contents* dialog box, see section 18.2.1.6 *Table objects*, page 51.

Refresh: Click to refresh the Table object contents. You usually only have to do this if you have changed the contents manually.

18.4.9 Summary Table object

18.4.9.1 General

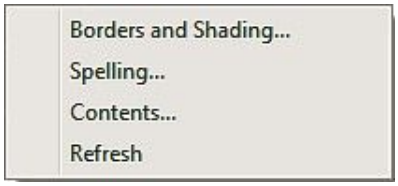
A Summary Table object lists infrared data of your choice from all infrared images in the report, one row per image.

You can edit the text in the Summary Table object, once the report is created. However, these changes will be deleted when you right-click the Summary Table object and select *Refresh*.

Image Date	Image Time	Reflected Temperature
2012-03-20	07:37:15	20.0 °C
2012-02-27	16:47:10	20.0 °C

18.4.9.2 Summary Table object shortcut menu

The Summary Table object shortcut menu is displayed when right-clicking a Summary Table object.



Borders and Shading: Click to open the standard Microsoft Word feature.

Spelling: Click to open the standard Microsoft Word feature.

Contents: Click to open the *Summary Table* dialog box, see section 18.2.1.7 *Summary Table objects*, page 52.

Refresh: Click to refresh the Summary Table object contents. You usually only have to do this if you have changed the contents manually.

18.4.10 Flir Tools+ dialog boxes

18.4.10.1 *QuickInsert* dialog box

In the *QuickInsert* dialog box, you can create a report by selecting a predefined page layout or modifying an existing page layout.

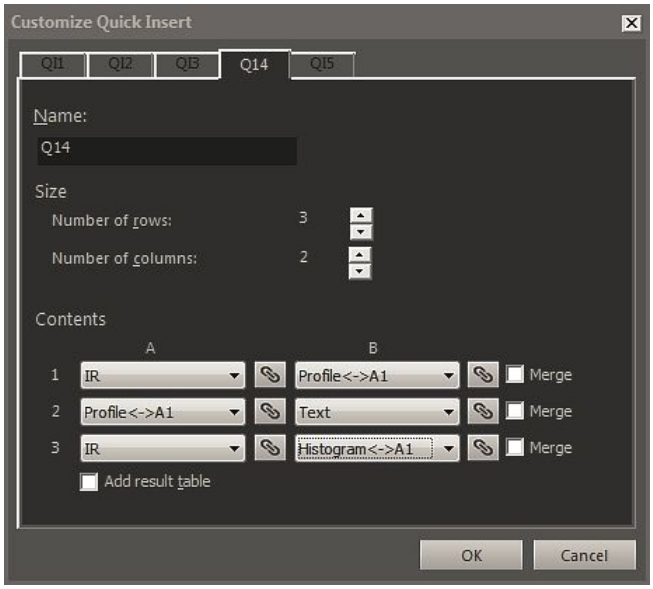
The *QuickInsert* dialog box is displayed when you click *QuickInsert* on the Flir Tools+ tab.

Select a tab and click *OK* to include a page layout in your report.

Customize Quick Insert: Click to open the *Customize Quick Insert* dialog box, see section 18.4.10.1.1 *Customize Quick Insert dialog box*, page 76.

18.4.10.1.1 Customize Quick Insert dialog box

The *Customize Quick Insert* dialog box is displayed when you click *Customize Quick Insert* in the *QuickInsert* dialog box.



Name: The name of the page layout you are currently creating.

Size > *Number of rows*: The number of rows in the page layout. *Example:* One infrared image above one photo equals two rows.

Size > *Number of columns*: The number of columns in the page layout. *Example:* One infrared image next to one photo equals two columns.

Contents: A visual representation of the page layout. The numbers refer to the rows and the capital letters refer to the columns.

Merge: When checked, *Merge* will merge two horizontal items into one single item. Note that the *Merge* command prioritizes the first item in a row.

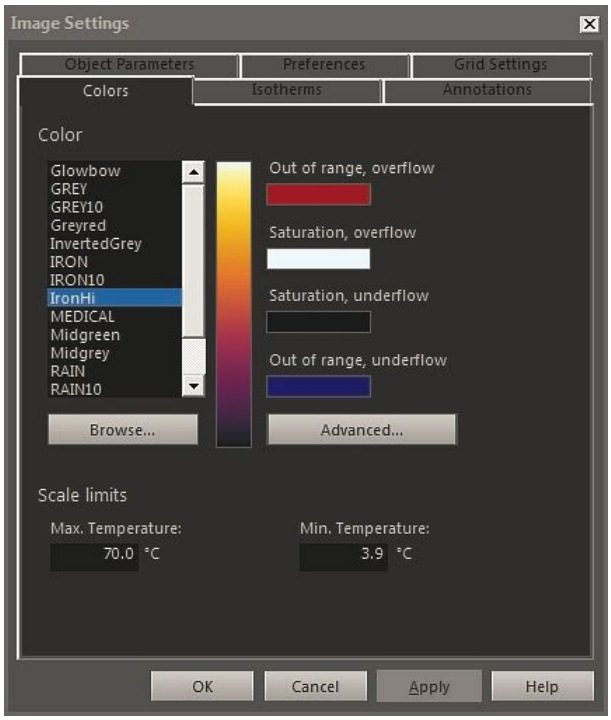
Click to open a dialog box where you can connect, or link, two objects.

Add a result table: To add a result table below your page layout, select this box.

18.4.10.2 *Image Settings* dialog box

The *Image Settings* dialog box is displayed when you right-click an IR Viewer object and select *Settings* from the shortcut menu.

18.4.10.2.1 Colors tab



Color: Click a palette in the list to select a palette.

Out of range, overflow: Displays the color assigned for the temperatures over the calibrated temperature range of the infrared camera.

Saturation, overflow: Displays the color assigned for the temperatures over the scale limits.

Saturation, underflow: Displays the color assigned for the temperatures under the scale limits.

Out of range, underflow: Displays the color assigned for the temperatures under the calibrated temperature range of the infrared camera.

Browse: Click to open palette files (*.pal) stored at a different location.

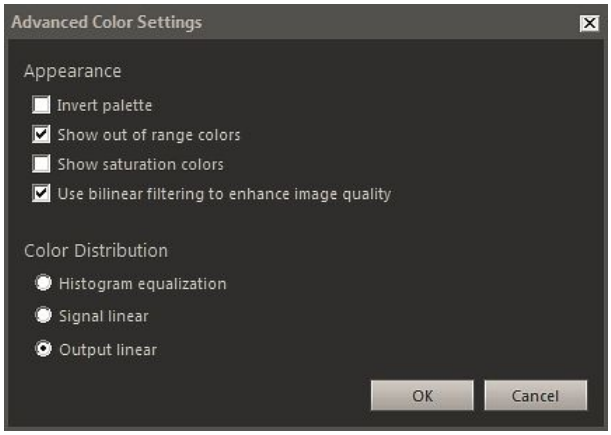
Advanced: Click to open the *Advanced Color Settings* dialog box, see section 18.4.10.2.1.1 *Advanced Color Settings dialog box*, page 78.

Max. Temperature: To define the maximum level temperature of the scale, type a temperature value in the text box.

Min. Temperature: To define the minimum level temperature of the scale, type a temperature value in the text box.

18.4.10.2.1.1 Advanced Color Settings dialog box

The *Advanced Color Settings* dialog box is displayed when you click *Advanced* in the *Image Settings* dialog box.



Invert palette: Check this box to invert the color distribution in a palette vertically.

Show out of range colors: Check this box to assign a special color for temperatures outside the calibrated temperature range of the infrared camera.

Show saturation colors: Check this box to assign a special color for the temperatures outside the scale limits.

Use bilinear filtering to enhance image quality: Check this box to improve the image quality.

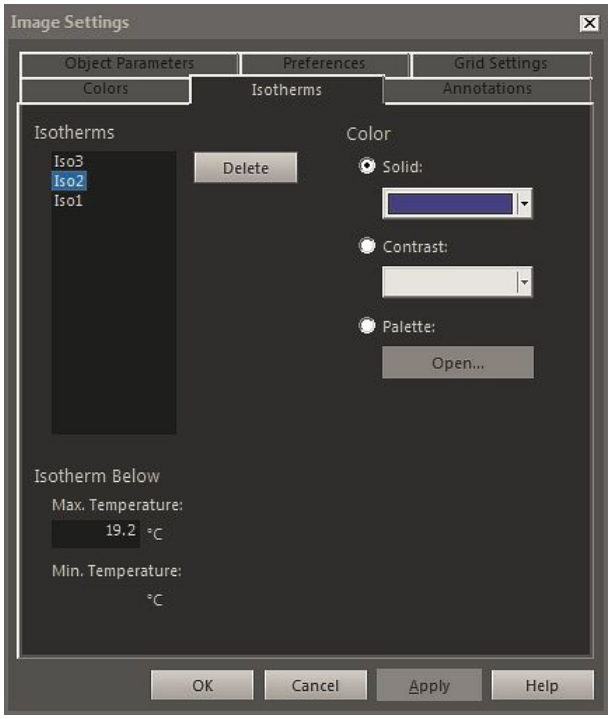
Histogram equalization: This is an image-displaying method that evenly distributes the color information over the existing temperatures of the image. This method to distribute the information can be particularly successful when the image contains few peaks of very high temperature values.

Signal linear: This is an image-displaying method where the color information in the image is distributed linearly to the signal values of the pixels.

Output linear: This selection works in conjunction with the settings under *Preferred output* on the *Preferences* tab, see section 18.4.10.2.5 *Preferences tab*, page 86.This is an image-displaying method where you can distribute the colors either according to the temperature or according to the object signal.

18.4.10.2.2 Isotherms tab

On the *Isotherms* tab you manage settings for isotherms and alarms that you have inserted with the tool, see section 18.4.2.3 *IR Viewer toolbar*, page 69.



Isotherms: Select an isotherm from the list.

Delete: Click to delete the active isotherm.

Solid: Select this option to assign a solid color to the active isotherm. Select the color from the drop-down list.

Contrast: Select this option to assign a contrasting color to the active isotherm. Select the color from the drop-down list.

Palette: Select this option and click *Open* to open a palette and use this palette for the active isotherm.

Max. Temperature: Click to set the maximum temperature of the active isotherm, enter a new value here and click *Apply*. Isotherms may exist outside the temperature range of the current image, which will make the isotherm invisible. By changing the maximum temperature, invisible isotherms can be brought back into range.

Min. Temperature: Click to set the minimum temperature of the active isotherm, enter a new value here and click *Apply*. Isotherms may exist outside the temperature range of the current image, which will make the isotherm invisible. By changing the minimum temperature, invisible isotherms can be brought back into range.

The appearance of the *Isotherms* tab is slightly different if a humidity or an insulation alarm is active, see sections below.

18.4.10.2.2.1 Isotherms tab with a humidity alarm

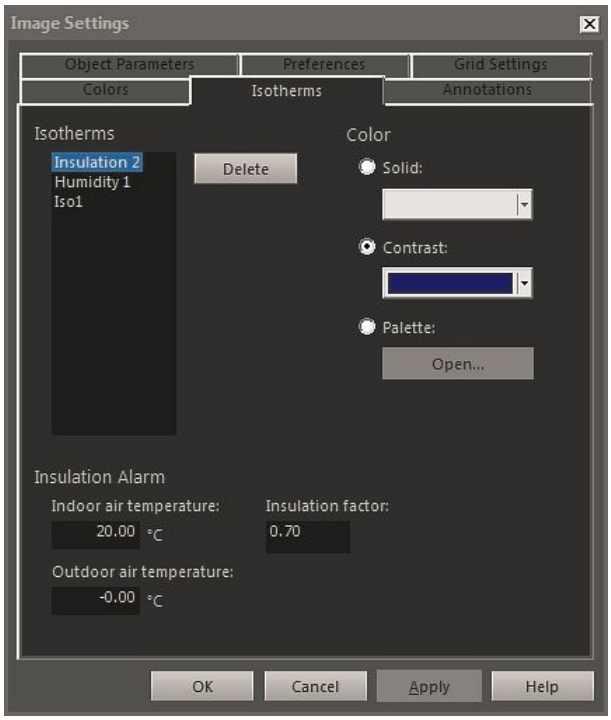
Atmospheric Temperature: This parameter refers to the atmospheric temperature when setting up humidity alarms. A humidity alam is an alarm that can detect an area where there may be a risk of humidity in a building structure.

Relative air humidity: This parameter refers to the relative air humidity when setting up humidity alarms.

Humidity Alarm Level: The humidity alarm level is the critical limit of relative humidity that you want to detect in, e.g., a building structure. For example, mold will grow on areas where the relative humidity is less than 100%, and you may want to find such areas of interest.

Note
Refer to your national building code for recommendations.

18.4.10.2.2.2 Isotherms tab with an insulation alarm



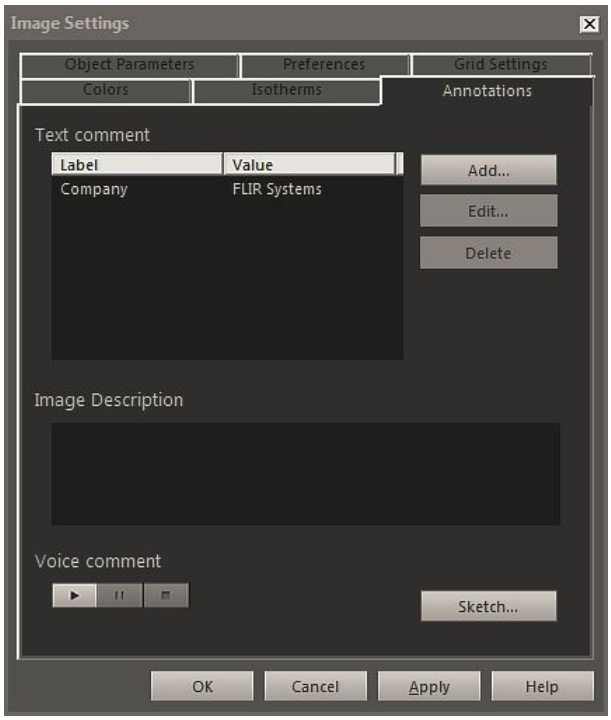
Indoor air temperature: This parameter refers to the air temperature inside the building in question when setting up insulation alarms. An insulation alarm is an alarm that can detect what may be an insulation deficiency in a wall.

Outdoor air temperature: This parameter refers to the air temperature outside the building in question when setting up insulation alarms.

Insulation factor: The insulation factor is the accepted energy loss through the wall. Different building codes recommend different values, but typical values are 0.70–0.80 for new buildings.

Note
Refer to your national building code for recommendations.

18.4.10.2.3 Annotations tab



Label: The label of a text comment.

Value: The value of a text comment.

Add: Click to display a dialog box where you can add a new text comment.

Edit: Click to display a dialog box where you can change the label and value.

Delete: To delete the text comment, select the text comment and then click *Delete*.

Image Description: An image description is a brief textual description that is stored inside an image file. It can be created using a Pocket PC and then beamed to the camera using the IrDA communication link. If the image has an image description, the text will be displayed in this edit box. If not, you can add an image description for the image by entering text. The maximum number of characters in an image description is 512.

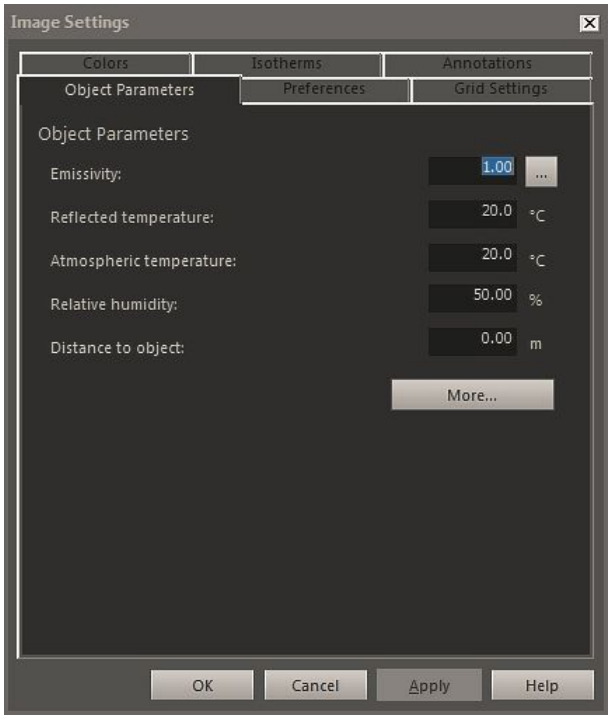
Click to listen to a voice comment.

Click to pause the current playback.

Click to stop the current playback.

Sketch: Click to display a dialog box where you can view a freehand sketch that is associated with an image. (Not all cameras support the creation of freehand sketches.)

18.4.10.2.4 Object Parameters tab



Emissivity: To change the emissivity, enter a new value and click *Apply*. You can also select a preset emissivity from a table by clicking ....

Reflected temperature: To change the reflected apparent temperature, enter a new value and click *Apply*.

Atmospheric Temperature: To change the atmospheric temperature, enter a new value and click *Apply*.

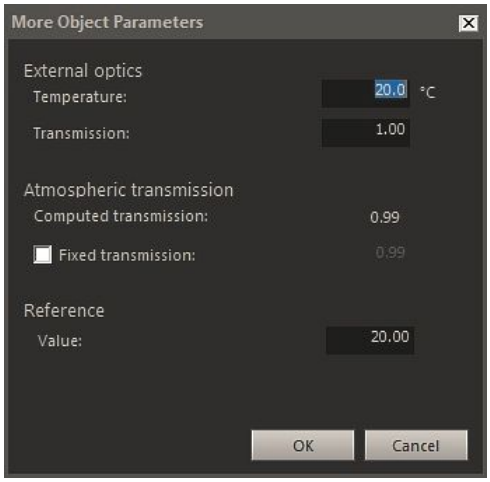
Relative humidity: To change the relative humidity, enter a new value and click *Apply*.

Distance to object: To change the distance, enter a new value and click *Apply*.

More: Click to open the *More Object Parameters* dialog box, see the section below.

Note
For more information about object parameters, see section 24 *Thermographic measurement techniques*, page 118.

18.4.10.2.4.1 More Object Parameters dialog box



Temperature: To specify the temperature of, e.g., an external lens or heat shield, enter a new value and click *OK* and then *Apply*.

Transmission: To specify the transmission of, e.g., an external lens or heat shield, enter a new value and click *OK* and then *Apply*.

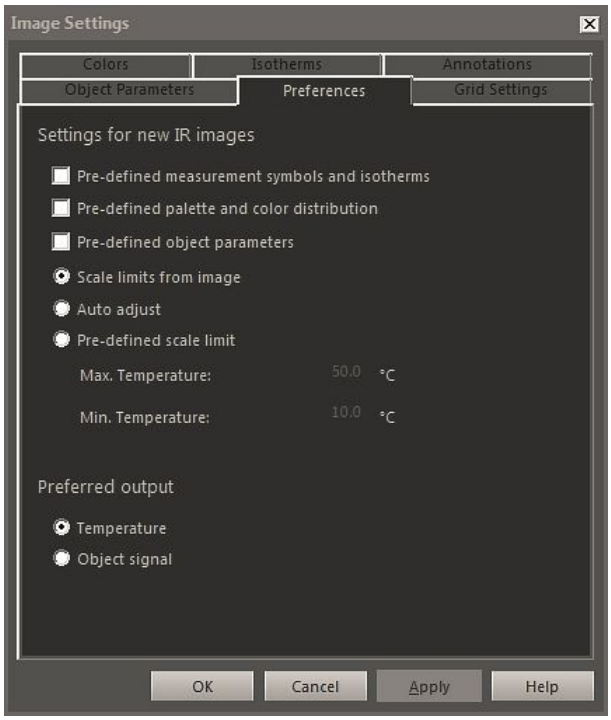
Computed transmission: Flir Tools+ can compute the transmission based on the atmospheric temperature and the relative humidity. Clear the *Fixed transmission* check box to use the computed transmission.

Fixed transmission: To use a specific transmission, check this box, enter a value and click *OK* and then *Apply*.

Value: To specify the reference temperature, enter a value *OK* and then *Apply*.

Note
For more information about object parameters, see section 24 *Thermographic measurement techniques*, page 118.

18.4.10.2.5 Preferences tab



Pre-defined measurement symbols and isotherms: If this box is selected, all new images will use the analysis symbols and isotherms that you set up in the *Image Settings* dialog box, instead of using the image's own settings from the camera.

Pre-defined palette and color distribution: If this box is selected, all new images will use the palette and color distribution that you set up in the *Image Settings* dialog box, instead of using the image's own settings from the camera.

Pre-defined object parameters: If this box is selected, all new images will use the object parameters that you set up in the *Image Settings* dialog box, instead of using the image's own settings from the camera.

Scale limits from image: Select this option to use the new image's scale limits.

Auto-adjust: Select this option to auto-adjust the image when importing it.

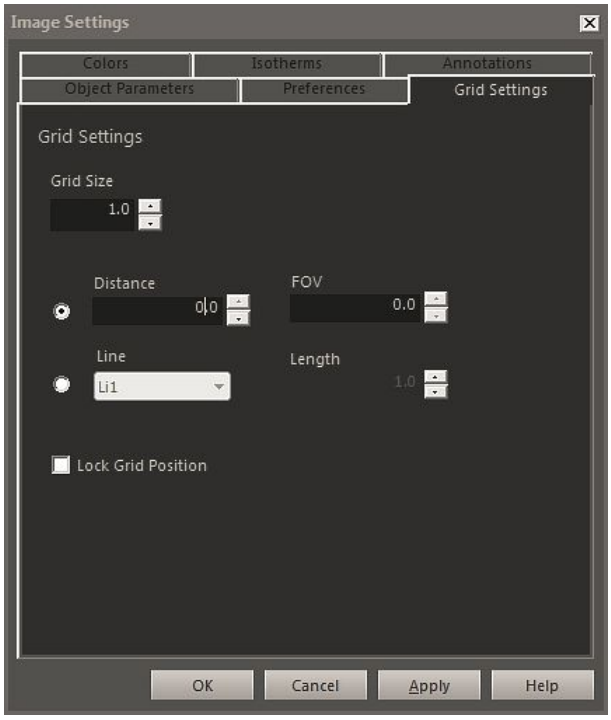
Max. Temperature: To predefine the scale limit for the new image, enter the maximum temperature level here and click *Apply*.

Min. Temperature: To predefine the scale limit for the new image, enter the minimum temperature level here and click *Apply*.

Temperature: Select this option to output the pixel information as temperature in kelvin, degrees Celsius, or degrees Fahrenheit.

Object signal: Select this option to output the pixel information as an object signal.

18.4.10.2.6 Grid Settings tab

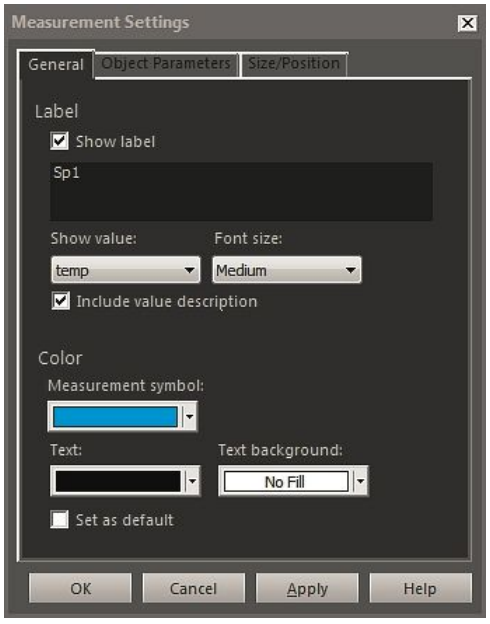


For an explanation of the items on the *Grid Settings* tab, see section 18.2.5.2 *Using the Grid tool*, page 56.

18.4.10.3 *Measurement Settings* dialog box

The *Measurement Settings* dialog box is displayed when you right-click an IR Viewer measurement tool and select *Settings* from the shortcut menu.

18.4.10.3.1 General tab



Label: To specify a label (i.e., a name appearing in the infrared image) for this measurement tool, enter a name here and click *Apply*.

Show label: To show the label for the measurement tool, check the *Show label* box and click *Apply*.

Show value: To display the value of the measurement tool (i.e., the measurement result) in the infrared image, select the value type and click *Apply*. The number of possible value types differs between different measurement tools.

Font size: To specify the font size of the label, select a font size in the *Font size* box and click *Apply*.

Include value description: To display the value description in the infrared image, check the *Include value description* box and click *Apply*.

Measurement symbol: To specify the color of the symbol for the measurement tool, select a color in the *Measurement symbol* box and click *Apply*.

Text: To specify the color of the label text, select a color in the *Text* box and click *Apply*.

Text background: To specify the color of the background, select a color in the *Text background* box and click *Apply*.

Set as default: To use these settings as default settings for all measurement tools, check the *Set as default* box and click *Apply*.

18.4.10.3.2 Object Parameters tab

Custom: To specify custom parameters, select *Custom*, enter new values in the three text boxes and click *Apply*.

Emissivity: To change the emissivity, enter a new value and click *Emissivity*. You can also select a preset emissivity from a table by clicking ....

Distance to object: To change the distance, enter a new value and click *Apply*.

Reflected apparent temperature: To change the reflected apparent temperature, enter a new value and click *Apply*.

Set as default: To use these object parameters settings as default settings for all measurement tools, check the *Set as default* box and click *Apply*.

Note
For more information about object parameters, see section 24 *Thermographic measurement techniques*, page 118.

18.4.10.3.3 Size/Position tab

X: To change the X position for a measurement tool, enter a negative or positive value and press *Apply* to move the measurement tool the same number of pixels, relative to its original position.

Y: To change the Y position for a measurement tool, enter a negative or positive value and press *Apply* to move the measurement tool the same number of pixels, relative to its original position.

Height: To change the height of a measurement tool, enter a value and press *Apply* to specify the new height of the measurement tool.

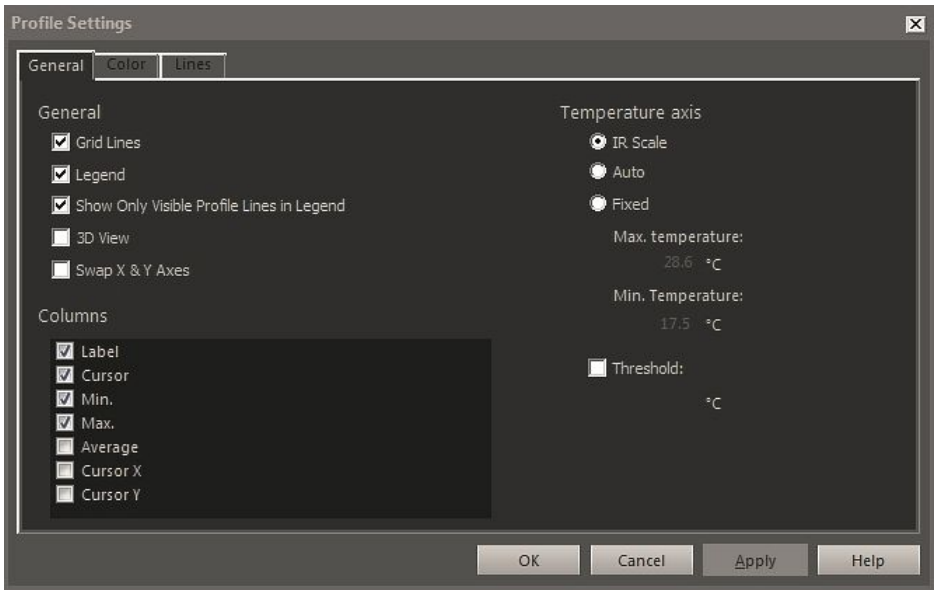
Width: To change the width of a measurement tool, enter a value and press *Apply* to specify the new width of the measurement tool.

Rotate: To rotate a measurement tool, enter a negative or positive value and press *Apply* to specify the new angle of rotation for the measurement tool.

18.4.10.4 *Profile Settings* dialog box

The *Profile Settings* dialog box is displayed when you right-click an IR Profile object and select *Settings* from the shortcut menu.

18.4.10.4.1 General tab



Grid Lines: To display a grid of horizontal lines in the IR Profile object, click *Grid Lines*.

Legend: To display a legend below the IR Profile object, click *Legend*.

Show Only Visible Profile Lines in Legend: If two or more lines are laid out in the infrared image, clicking *Show Only Visible Profile Lines in Legend* will remove any cleared line results from the legend below the IR Profile object.

3D View: To create a three-dimensional rendering of the graph of the IR Profile object, click *3D View*.

Swap X & Y Axes: To swap the X and Y axes of the IR Profile object, click *Swap X & Y Axes*.

Columns: To add or remove columns in the IR Profile object, select or clear these boxes.

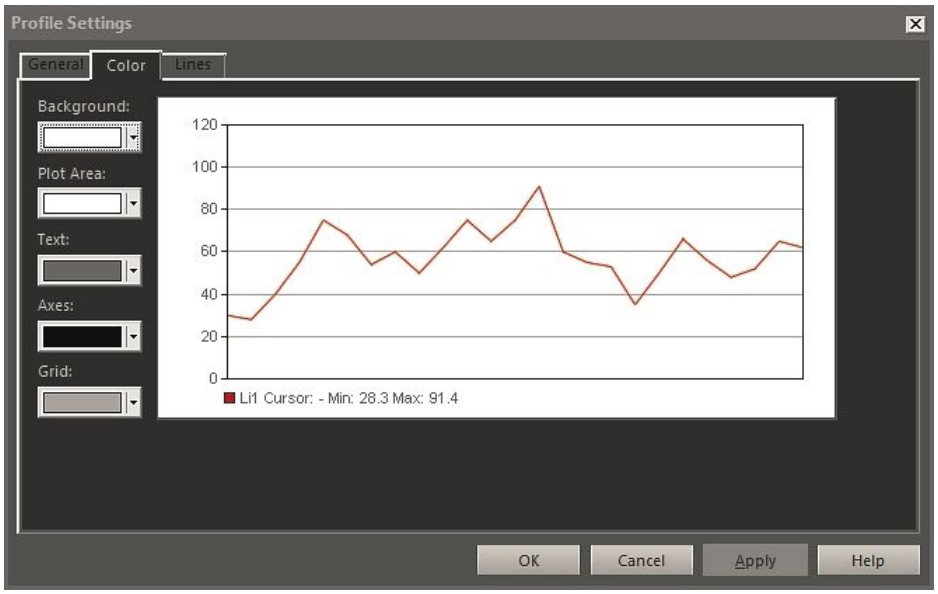
IR Scale: To use the infrared scale as the temperature axis, select this option button and click *Apply*.

Auto: To let Flir Tools+ automatically define the temperature axis, select this option button and click *Apply*.

Fixed: To manually define the maximum and minimum axis temperature, select this option button, enter new values in the *Max. Temperature* and *Min. Temperature* boxes, and click *Apply*.

Threshold: To display a horizontal line at a certain temperature in the IR Profile object, enter a value in the text box and click *Apply*.

18.4.10.4.2 Color tab



Background: To change the color of the table background, select a new color from the drop-down list box and click *Apply*.

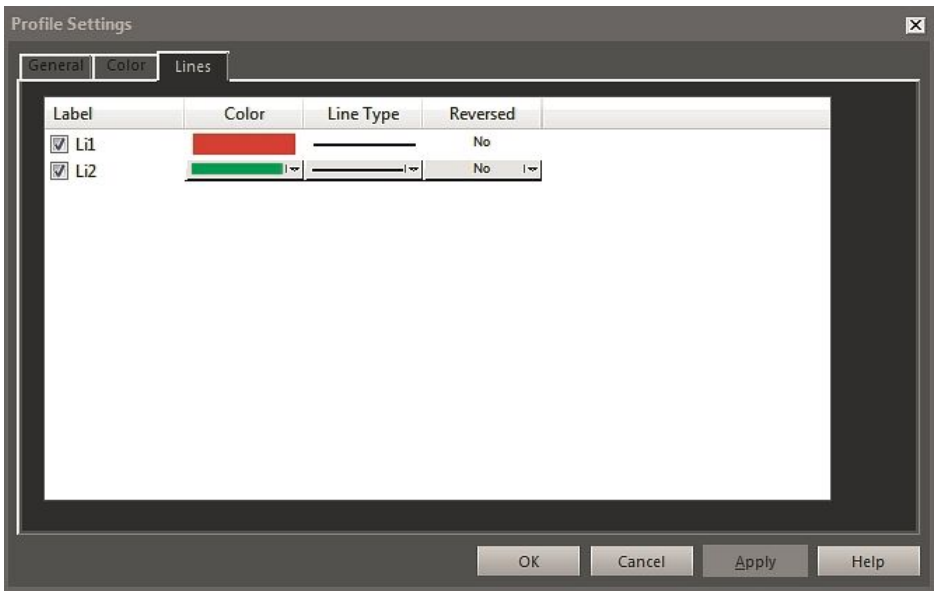
Plot Area: To change the color of the plot area, select a new color from the drop-down list box and click *Apply*.

Text: To change the color of the table text, select a new color from the drop-down list box and click *Apply*.

Axes: To change the color of the axes, select a new color from the drop-down list box and click *Apply*.

Grid: To change the color of the grid lines, select a new color from the drop-down list box and click *Apply*.

18.4.10.4.3 Lines tab



Use the check boxes to select which lines that you want to connect the IR Profile object to and click *Apply*.

Color: To change the color of a line, select a new color from the drop-down list box and click *Apply*.

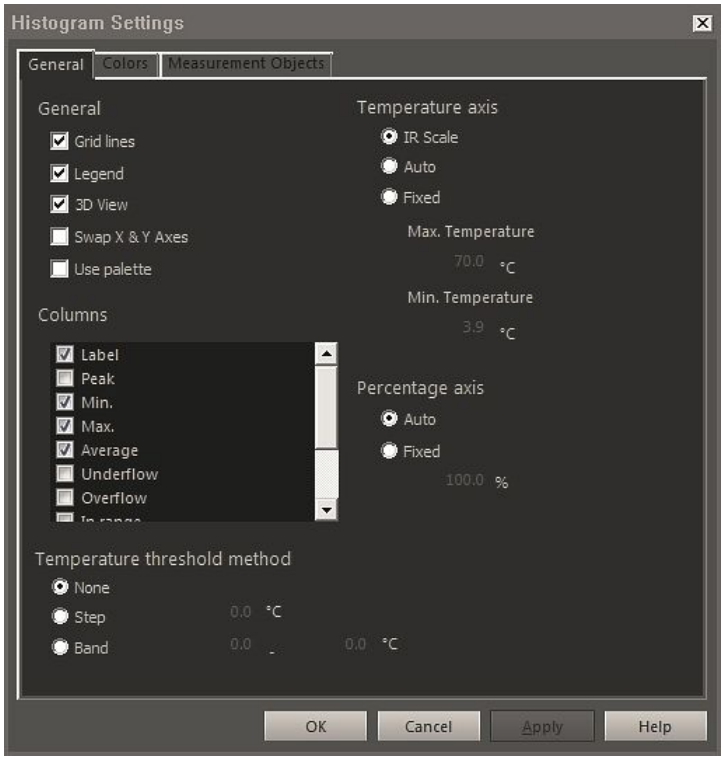
Line Type: To change the line type of a line, select a new line type from the drop-down list box and click *Apply*.

Reversed: To reverse direction of the graph, select *Yes* from the drop-down list box and click *Apply*.

18.4.10.5 *Histogram Settings* dialog box

The *Histogram Settings* dialog box is displayed when you right-click an IR Histogram object and select *Settings* from the shortcut menu.

18.4.10.5.1 General tab



Grid Lines: To display a grid of horizontal lines in the IR Histogram object, click *Grid Lines*.

Legend: To display a legend below the IR Histogram object, click *Legend*.

3D View: To create a three-dimensional rendering of the graph of the IR Histogram object, click *3D View*.

Swap X & Y Axes: To swap the X and Y axes of the IR Histogram object, click *Swap X & Y Axes*.

Use palette: To use a color palette for the three-dimensional rendering of the IR Histogram object, select *Use palette* and click *Apply*.

Columns: To add or remove columns in the IR Histogram object, select or clear these boxes.

None: Select this option button if no threshold should be used in the IR Histogram object.

Step: To use a *step* threshold in the IR Histogram object, select this option button. A *step* threshold shows the percentage of pixels below and above a specific temperature. The percentages are displayed in the IR Histogram object legend below the IR Histogram object.

Band: To use a *band* threshold in the IR Histogram object, select this option button. A *band* threshold shows the percentage of pixels below a lower temperature, between this lower temperature and a higher temperature, and above that higher temperature. The percentages are displayed in the threshold legend below the IR Histogram object.

IR Scale: To use the infrared scale as the temperature axis, select this option button and click *Apply*.

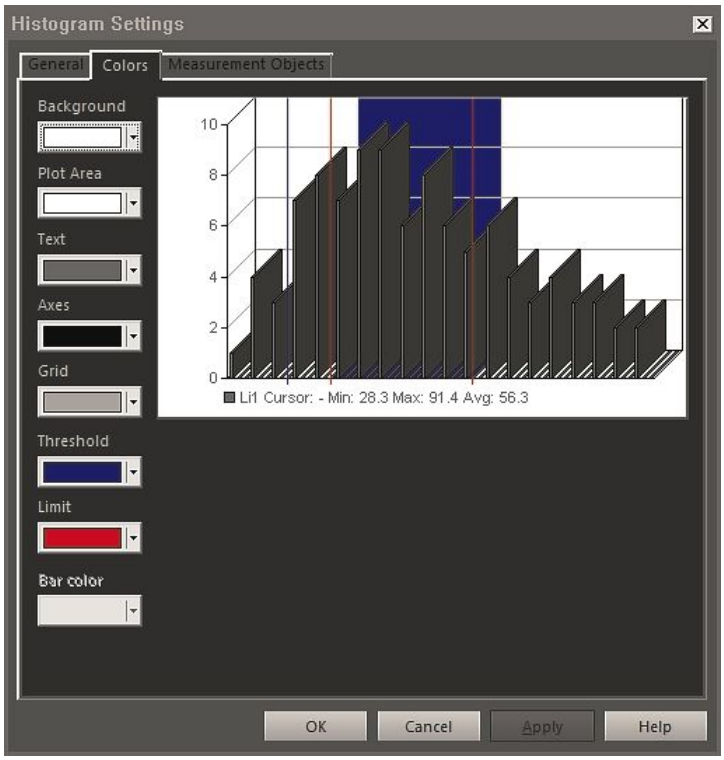
Auto: To let Flir Tools+ automatically define the temperature axis, select this option button and click *Apply*.

Fixed: To manually define the maximum and minimum axis temperature, select this option button, enter new values in the *Max. Temperature* and *Min. Temperature* boxes and click *Apply*.

Percentage axis > *Auto*: To let Flir Tools+ automatically define the percentage axis, select this option button and click *Apply*.

Percentage axis > *Fixed*: To manually define the percentage axis, select this option button, enter a new value, and click *Apply*.

18.4.10.5.2 Color tab



Background: To change the color of the table background, select a new color from the drop-down list box and click *Apply*.

Plot Area: To change the color of the plot area, select a new color from the drop-down list box and click *Apply*.

Text: To change the color of the table text, select a new color from the drop-down list box and click *Apply*.

Axes: To change the color of the axes, select a new color from the drop-down list box and click *Apply*.

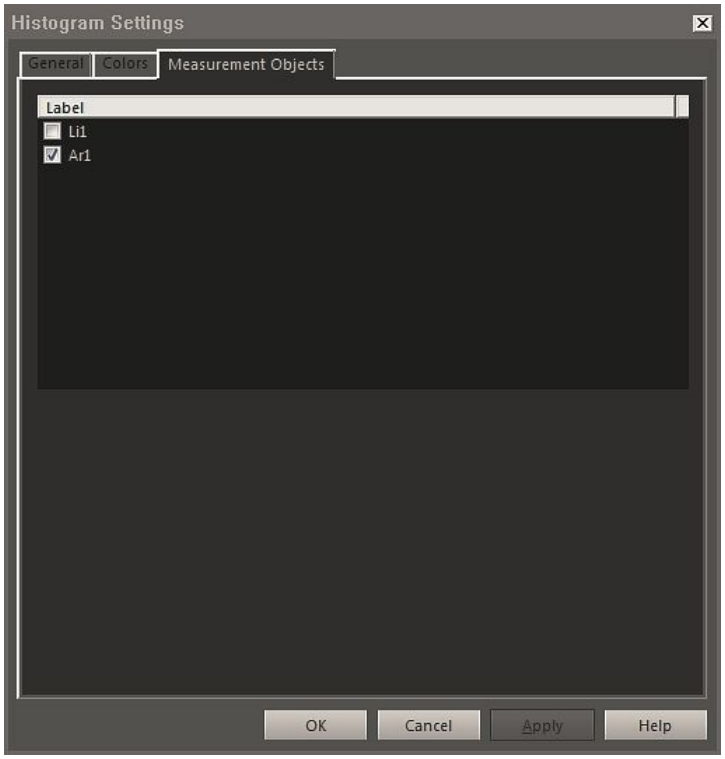
Grid: To change the color of the grid lines, select a new color from the drop-down list box and click *Apply*.

Threshold: To change the color of the threshold, select a new color from the drop-down list box and click *Apply*.

Limit: To change the color of the limit, select a new color from the drop-down list box and click *Apply*.

Bar color: To change the color of the bar color, select a new color from the drop-down list box and click *Apply*.

18.4.10.5.3 Measurement Objects tab

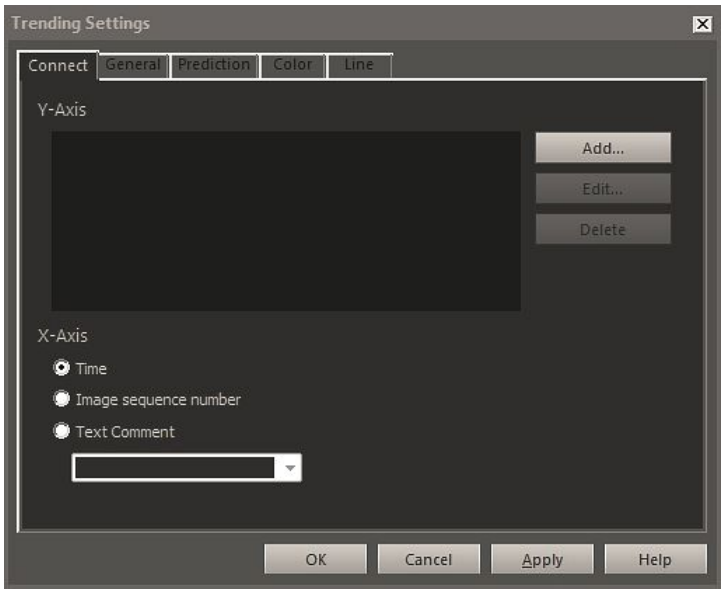


Use the check boxes to specify which line that you want to connect the IR Histogram object to and click *Apply*.

18.4.10.6 *Trending Settings* dialog box

The *Trending Settings* dialog box is displayed when you right-click an IR Trending object and select *Settings* from the shortcut menu.

18.4.10.6.1 Connect tab



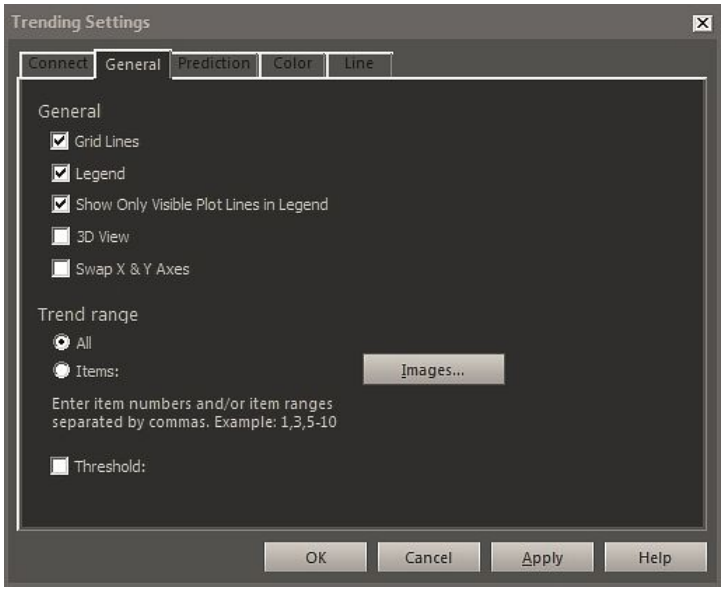
Y Axis: To specify a parameter for the Y axis, click *Add* and select a label and value for it in the left and right panes, respectively.

Time: To specify time as the X-axis parameter, select the *Time* option button.

Image sequence number: To specify an incrementally stepped image sequence number as the X-axis parameter, select the *Image sequence number* option button.

Text Comment: To specify text comments as the X-axis parameter, select the *Text Comment* option button. When using text comments as the X-axis parameter, all images must have the same text comment label. The value of the text comment must be a numerical value.

18.4.10.6.2 General tab



Grid Lines: Click to display a grid of horizontal lines in the IR Trending object.

Legend: Click to display a legend below the IR Trending object.

Show Only Visible Plot Lines in Legend: Click to display trend lines in the legend that you have cleared on the*Line* tab.

3D View: Click to create a three-dimensional rendering of the graph of the IR Trending object.

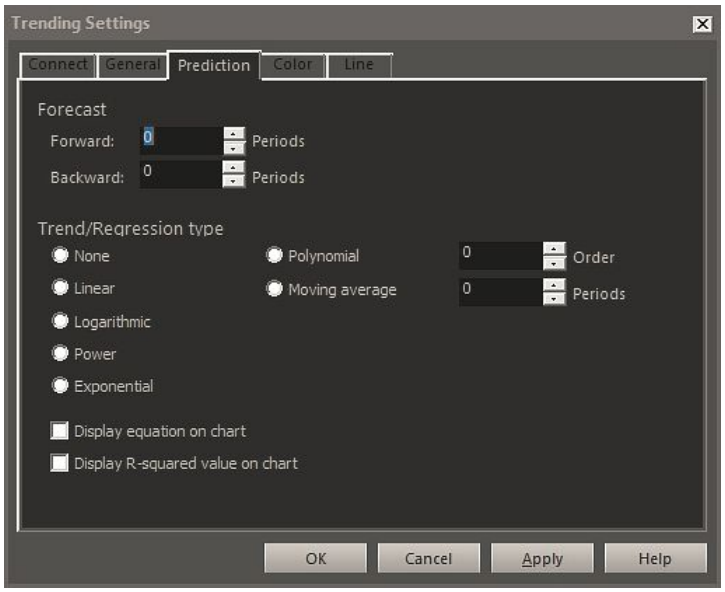
Swap X & Y Axes: Click to swap the X and Y axes of the IR Trending object.

All: To include all images for the trend, select the *All* option button.

Items: To include a range of adjacent or non-adjacent images, click *Images* and select the images that you want to include.

Threshold: To display a horizontal baseline in the IR Trending object, enter a value.

18.4.10.6.3 Prediction tab



Forward: To specify the number of periods forward for which the algorithms will present a probable trend, select a value in the *Forward* box.

Note
The probable trend is a mathematical approximation only.

Backward: To specify the number of periods backward for which the algorithms will present a probable trend, select a value in the *Backward* box.

Note
The probable trend is a mathematical approximation only.

None: To disable *Trend Regression type*, select *None*.

Linear: To use a linear trending algorithm, select *Linear*. This algorithm uses the following mathematical expression: $y = m \times x + c$.

Logarithmic: To use a logarithmic trending algorithm, select *Logarithmic*. This algorithm uses the following mathematical expression: $y = m \times \ln(x) + c$.

Power: To use a power trending algorithm, select *Power*. This algorithm uses the following mathematical expression: $y = ec \times x^m$.

Exponential: To use an exponential trending algorithm, select the *Exponential* option button. This algorithm uses the following mathematical expression: $y = \exp(c) \times e^{(m \times x)}$.

Polynomial: To use an polynomial trending algorithm, select the *Polynomial* option button. This algorithm uses the following mathematical expression: $y = a_0x^0 + a_1x^1 + a_2x^2 + ... + a_kx^k$, where k = order.

Moving average: To use a moving average trending algorithm, select the *Moving average* option button. This algorithm uses the following mathematical expression: an n period moving average = the average value over the previous n time periods.

Display equation on chart: To display the equation on the chart, select *Display equation on chart*.

Display R-squared value on chart: To display a numerical value that indicates how successfully the algorithm approximates the curve, select *Display R-squared value on chart*. The value is between 0 and 1, where 0 is poor quality and 1 is high quality.

18.4.10.6.4 Color tab

Background: To change the color of the table background, select a new color from the drop-down list box and click *Apply*.

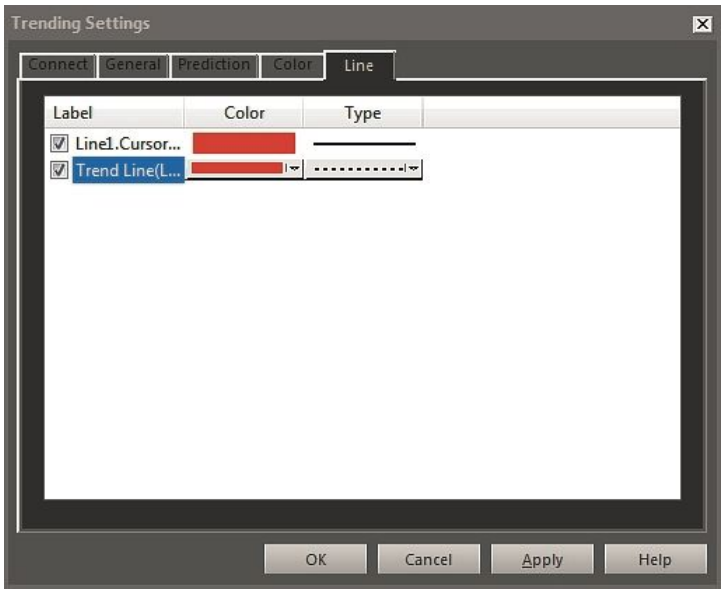
Plot Area: To change the color of the plot area, select a new color from the drop-down list box and click *Apply*.

Text: To change the color of the table text, select a new color from the drop-down list box and click *Apply*.

Axes: To change the color of the axes, select a new color from the drop-down list box and click *Apply*.

Grid: To change the color of the grid lines, select a new color from the drop-down list box and click *Apply*.

18.4.10.6.5 Line tab



Use the check boxes to select which lines that you want to display in the IR Trending object and click *Apply*.

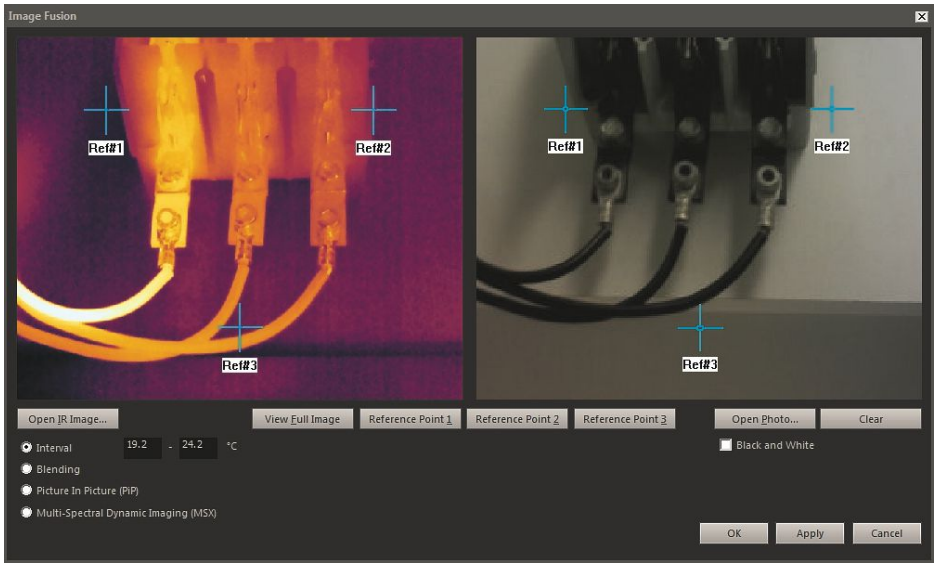
Color: To change the color of a line, select a new color from the drop-down list box and click *Apply*.

Line Type: To change the line type of a line, select a new line type from the drop-down list box and click *Apply*.

18.4.10.7 *Image Fusion* dialog box

In the *Image Fusion* dialog box, you can fuse an infrared image with a digital photo. Fusing images can make it easier to identify the exact position of temperature anomalies.

The *Image Fusion* dialog box is displayed when you click in the IR Viewer object toolbar. You can also display the dialog box by right-clicking the IR Viewer object and selecting *Image Fusion* from the shortcut menu.



Open IR Image: Click to select an infrared image.

View Full Image: Click to view the full image.

Ref#1: Click to zoom in on crosshair *Ref#1*.

Ref#2: Click to zoom in on crosshair *Ref#2*.

Ref#3: Click to zoom in on crosshair *Ref#3*.

Open Photo: Click to select a digital photo.

Black and White: Check to display the digital photo in grayscale.

Clear: Click to remove the digital photo.

Interval: Select this option to use one temperature interval for the infrared image and to use the digital photo for lower and higher temperatures. Enter the desired temperature values in the corresponding text boxes. You can adjust the temperature levels by dragging the sliders in the IR Viewer object, once you have closed the dialog box.

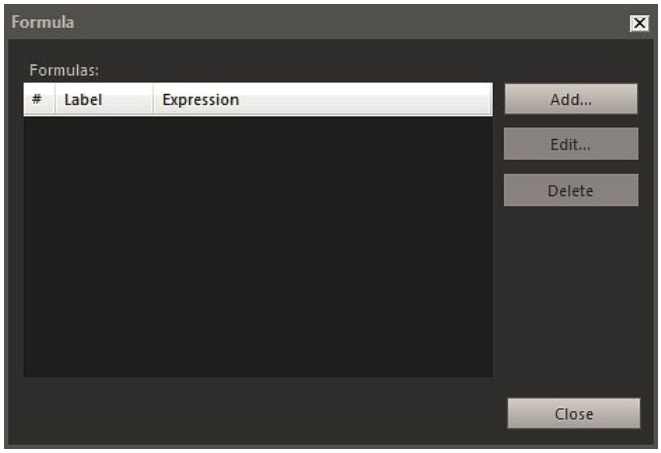
Blending: Select this option to blend the image from a mix of infrared pixels and digital photo pixels. You can adjust the mixing levels by dragging the sliders in the IR Viewer object, once you have closed the dialog box.

Picture in Picture (PiP): Select this option to display a portion of a digital photo as an infrared image. In the IR Viewer object, you can then move and resize the PIP anywhere in the photo to show the level of detail that you want in your report.

Multi-Spectral Dynamic Imaging (MSX): Select this option to enhance the contrast in the infrared image. This MSX fusion technology embosses digital camera details onto the infrared image, enabling a sharper-looking infrared image and quicker target orientation.

18.4.10.8 *Formula* dialog box

The *Formula* dialog box is displayed when you right-click the IR Viewer object and select *Formulas* from the shortcut menu.



Add: Click *Add* to display a dialog box in which you define your new formula.

Edit: Select a formula and click *Edit* to display a dialog box in which you edit your formula.

Delete: Select a formula and click *Delete* to delete.

For more information about how you define formulas, see section 18.2.6 *Formulas*, page 57.

18.5 Supported file formats in the IR Viewer object

The IR Viewer object supports the following radiometric file formats:

- ThermaCAM radiometric *.jpg.
- ThermaCAM radiometric *.img.
- ThermaCAM radiometric 8-bit *.tif.
- ThermaCAM radiometric 8/12-bit *.tif.

- ThermaCAM radiometric 12-bit *.tif.
- ThermoTeknix *.tgw.
- ThermoTeknix *.tmw.
- ThermoTeknix *.tlw.
- ThermaCAM radiometric *.seq (radiometric sequence files).

19 Updating the camera and PC software

19.1 Updating the PC software

19.1.1 General

You can update Flir Tools/Tools+ with the latest service packs.

19.1.2 Procedure

Follow this procedure:

1. Start Flir Tools/Tools+.
2. On the *Help* menu, select *Check for updates*. This displays a dialog box.

Figure 19.1 Flir Tools/Tools+ update dialog box (example image)

3. Follow the on-screen instructions.

19.2 Updating the camera firmware

19.2.1 General

You can update your infrared camera with the latest firmware.

Note
Before updating the camera you must update Flir Tools/Tools+.

19.2.2 Procedure

Follow this procedure:

1. Connect your infrared camera to a PC.
2. Start Flir Tools/Tools+.
3. On the *Help* menu, select *Check for updates*. This displays a dialog box.

Figure 19.2 Camera update dialog box (example).

4. Follow the on-screen instructions.

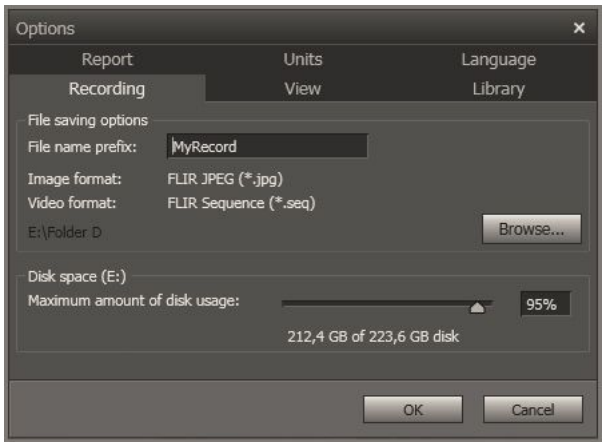
20 Changing settings

20.1 Settings relating to Flir Tools/Tools+

20.1.1 General

You can change a variety of settings relating to report and imagesheet creation, as well as settings relating to the software.

20.1.2 Recording tab



File name prefix: The prefix that shall be inserted in file names for recordings.

Image format: The image format for snapshots that are saved as image files from recordings.

Video format: The video format for recordings.

Browse: Click *Browse* to specify the location where video recordings shall be saved.

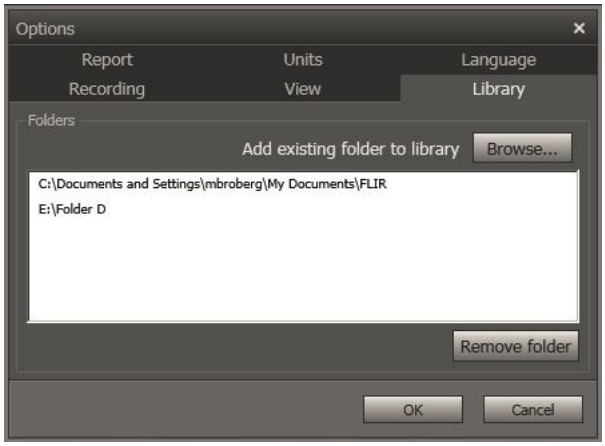
Disk space: The available disk space for recordings.

20.2 *View* tab

Hide cold and hot spot: To hide any existing cold and hot spots in an image, select this check box.

Show wizard when connecting a camera: To display the import guide when connecting a camera, select this checkbox.

20.3 *Library* tab



Add existing folder to library: To add an existing folder on your computer to the image library, click *Browse* and navigate to the folder.

Remove folder: To remove a folder from the image library, select the folder in the folder list and then click *Remove folder*.

20.4 *Report* tab

Page size: To change the page size, select a new page size in the list. Available options are *A4*, *US Letter*, and *US Legal*.

Show all parameters: To display all measurement parameters for an image when included in a report, select this checkbox.

Extract digital camera image from thermal image (if available) when generating: For cameras supporting thermal fusion, all image modes are included inside a single image file—MSX, thermal, thermal fusion, picture-in-picture, and the digital camera image. To extract the digital camera image when generating a report, select this checkbox.

Built-in templates path: The file path to the program's built-in templates.

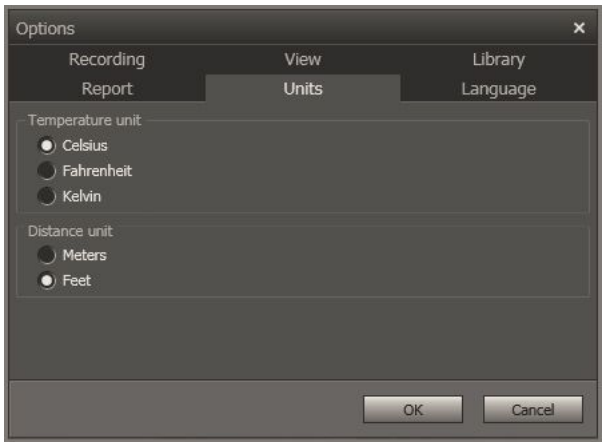
User templates path: The file path to the program's user templates.

Logo: To display a logo in the top left corner of the report pages, select this checkbox. To display another logo, click *Browse* and navigate to the logo file.

Header: A text field where you can enter any text that shall be displayed in the report header.

Footer: A text field where you can enter any text that shall be displayed in the report footer.

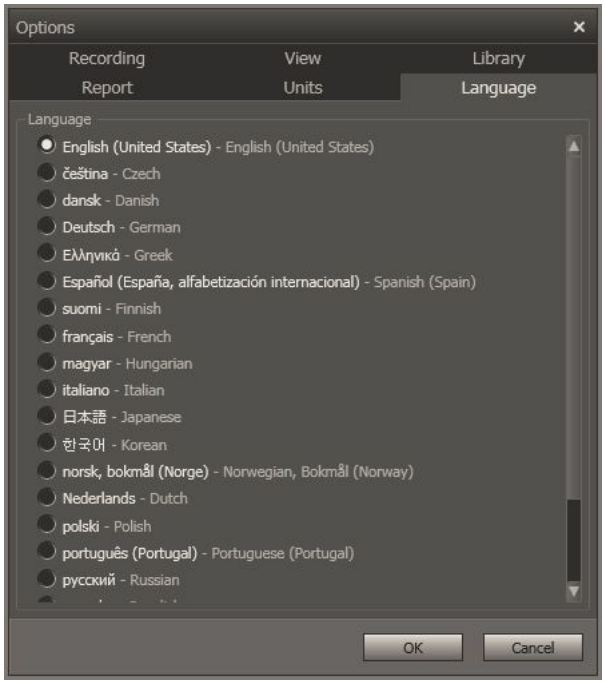
20.5 *Units* tab



Temperature unit: The unit for temperature values in the program and the reports. To change the unit, select another unit. Available options are *Celsius*, *Fahrenheit*, *Kelvin*.

Distance unit: The unit for distance in the program and the reports. To change the unit, select another unit. Available options are *Meters*, *Feet*.

20.6 *Language* tab



Language: To change the language, select a new language in the list.

20.7 Settings relating to Flir K series cameras

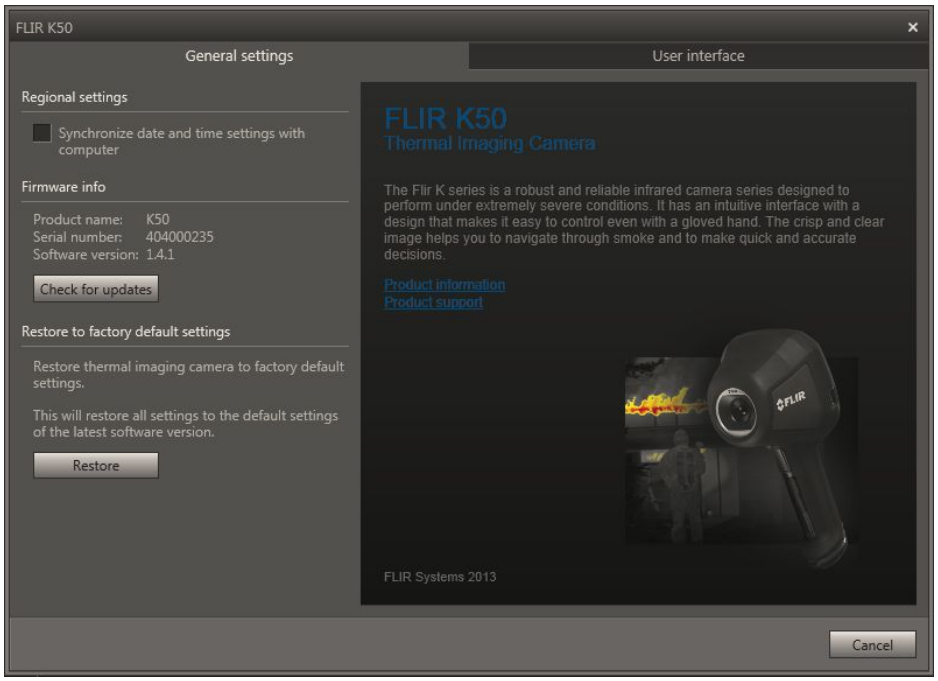
20.7.1 General

The Flir K series is a robust and reliable infrared camera series designed to perform under extremely severe conditions. It has an intuitive interface with a design that makes it easy to control even with a gloved hand. The crisp and clear image helps you to navigate through smoke and to make quick and accurate decisions.

By connecting a Flir K series camera to Flir Tools/Tools+, you get access to a variety of settings in the camera.

20.7.2 The General settings tab

20.7.2.1 Figure


FLIR K50
General settings
User interface
Regional settings
Synchronize date and time settings with computer
Firmware info
Product name: K50
Serial number: 404000235
Software version: 1.4.1
Check for updates
Restore to factory default settings
Restore thermal imaging camera to factory default settings.
This will restore all settings to the default settings of the latest software version.
Restore
FLIR K50
Thermal Imaging Camera
The Flir K series is a robust and reliable infrared camera series designed to perform under extremely severe conditions. It has an intuitive interface with a design that makes it easy to control even with a gloved hand. The crisp and clear image helps you to navigate through smoke and to make quick and accurate decisions.
Product information
Product support
FLIR Systems 2013
Cancel

20.7.2.2 Explanation

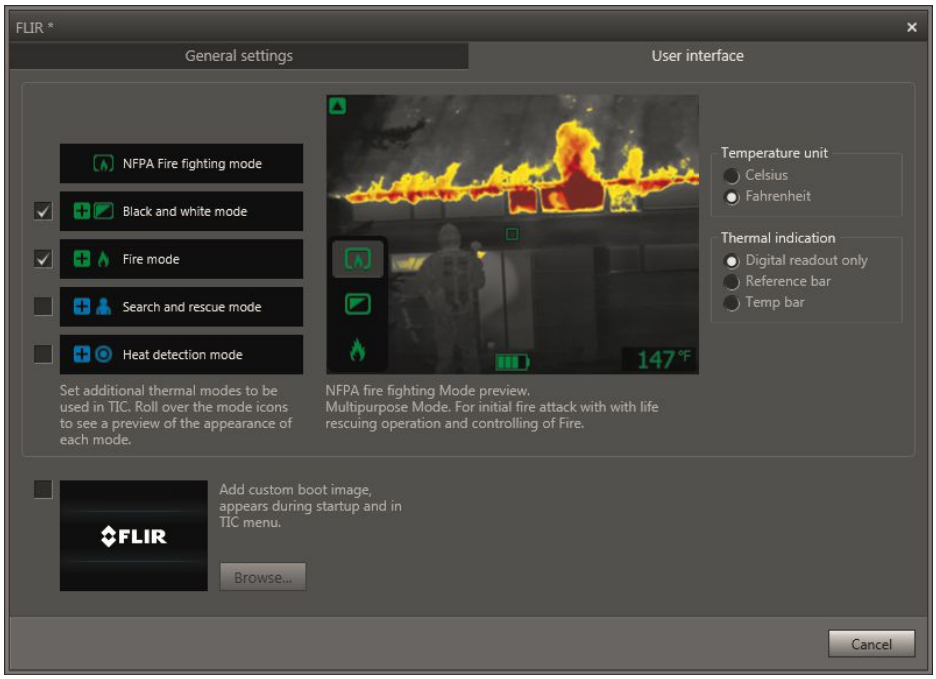
Regional settings area: To synchronize the camera's date and time settings with the computer, select the checkbox.

Firmware info area: To check whether a newer version of the camera firmware exists, click *Check for updates*, and follow the on-screen instructions.

Restore to factory default area: To restore all camera settings to the factory defaults, click *Restore*.

20.7.3 The User interface tab

20.7.3.1 Figure


FLIR *
General settings
User interface
NFPA Fire fighting mode
Black and white mode
Fire mode
Search and rescue mode
Heat detection mode
Set additional thermal modes to be used in TIC. Roll over the mode icons to see a preview of the appearance of each mode.
NFPA fire fighting Mode preview. Multipurpose Mode. For initial fire attack with with life rescuing operation and controlling of Fire.
147 °F
Temperature unit
Celsius
Fahrenheit
Thermal indication
Digital readout only
Reference bar
Temp bar
Add custom boot image, appears during startup and in TIC menu.
FLIR
Browse...
Cancel

20.7.3.2 Explanation

Camera modes area: To define which camera modes to enable in the camera, select the camera mode. For more information on each camera mode, see section 20.7.4 *Explanation of the different camera modes*, page 108.

Temperature unit area: To select a different temperature unit, click *Celsius* or *Fahrenheit*.

Thermal indication area > *Digital readout only*: To display the thermal information in the image as the temperature of the spotmeter only, select *Digital readout only*. In modes with automatic heat colorization, the colorization of the image will remain but the static heat color reference icon will not be displayed.

Thermal indication area > *Reference bar*: In modes with automatic heat indication colorization, a vertical heat color reference bar is displayed in the thermal indication area. This static icon shows how heat colors are applied to the range of the camera mode. The colors yellow, orange, and red correspond to a temperature-dependent change in hue as the temperature increases.

Thermal indication area > *Temp bar*: To display the thermal information in the image as a temperature bar, similar to a thermometer, click *Temp bar*. This displays a dynamic vertical temperature bar on the right side of the image. The top of the dynamic bar represents the temperature of the measured spot. In modes with automatic heat colorization, the colorization of the image will remain, with a static heat color reference icon displayed next to the temp bar.

Custom boot image area: To specify your own unique image to appear during start-up, click *Browse*, and navigate to the image file. This is useful for, for example, identifying your fire department cameras. By incorporating your fire department's logo, and a unique identity number in the image, you can keep track of your cameras. This image can also be accessed from the camera menu.

20.7.4 Explanation of the different camera modes

20.7.4.1 NFPA firefighting mode

Figure 20.1 NFPA firefighting mode.

The *NFPA standardized firefighting mode* is the default mode of the camera. It is a multipurpose mode for the initial fire attack with life rescuing operation and control of the fire. The camera automatically switches between the high-sensitivity range and the low-sensitivity range, to maintain an optimal infrared image while at the same time maintaining a safe and consistent heat colorization of the fire scene.

- Automatic range.
- Colorization of heat: +150 to +650°C (+302 to +1202°F).
- High-sensitivity range: –20 to +150°C (–4 to +302°F).
- Low-sensitivity range: 0 to +650°C (+32 to +1202°F).

20.7.4.2 Black and white firefighting mode

Figure 20.2 Black and white firefighting mode.

The *black and white firefighting mode* is an NFPA standardized firefighting mode. It is a multipurpose mode for the initial fire attack with life rescuing operation and control of the fire. It is specifically designed for fire services that do not want to use the heat colorization feature.

The camera automatically switches between the high-sensitivity range and the low-sensitivity range, to maintain an optimal infrared image.

- Automatic range.
- High-sensitivity range: –20 to +150°C (–4 to +302°F).
- Low-sensitivity range: 0 to +650°C (+32 to +1202°F).

20.7.4.3 Fire mode

Figure 20.3 Fire mode.

The *fire mode* is similar to the NFPA standardized firefighting mode, but with a higher-temperature starting point for the heat colorization. It is suitable for fire scenes with higher background temperatures, where there are already a lot of open flames and a high background temperature. The camera automatically switches between the high-sensitivity range and the low-sensitivity range, to maintain an optimal infrared image while at the same time maintaining a safe and consistent colorization of heat.

- Automatic range.
- Colorization of heat: +250 to +650°C (+ 482 to +1202°F).
- High-sensitivity range: –20 to +150°C (–4 to +302°F).
- Low-sensitivity range: 0 to +650°C (+32 to +1202°F).

20.7.4.4 Search and rescue mode

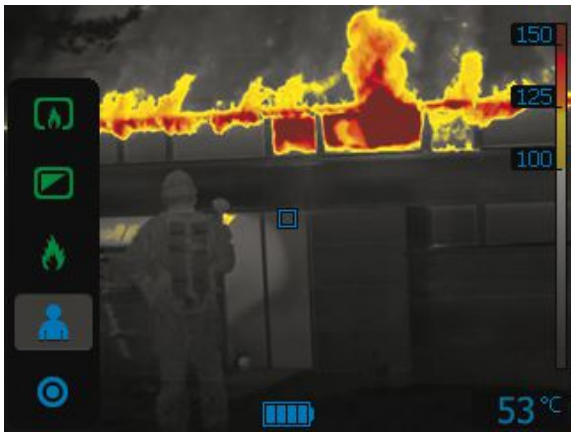


Figure 20.4 Search and rescue mode.

The *search and rescue mode* is optimized for maintaining high contrast in the infrared image while searching for people in landscapes, buildings, or traffic accident scenes.

- High sensitivity range only.
- Colorization of heat: +100 to +150°C (+212 to +302°F).
- High-sensitivity range: –20 to +150°C (–4 to +302°F).

20.7.4.5 Heat detection mode

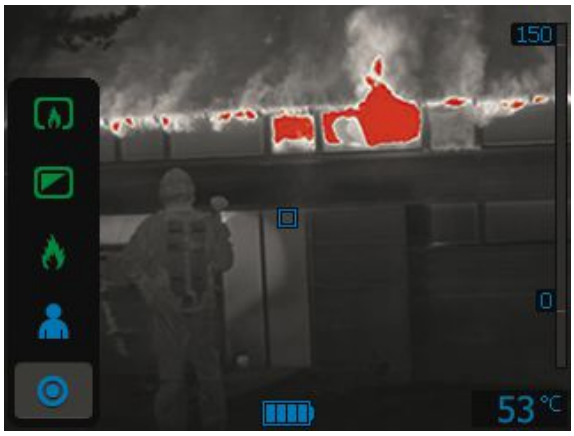


Figure 20.5 Heat detection mode.

The *heat detection mode* is optimized for searching hotspots during overhaul after the fire is out—typically to ensure that there is no hidden fire left. This mode can also be used to find thermal patterns, for example signs of people in car seats after accidents, to ensure that everyone has been found. This mode can also be used to search for people in water and open landscapes.

- High-sensitivity range only.
- Colorization of heat: the 2% hottest area in the scene.
- High-sensitivity range: +100 to +150°C (+212 to +302°F).

21 Supported file formats

21.1 General

Flir Tools/Tools+ supports several radiometric and non-radiometric file formats.

21.2 Radiometric file formats

Flir Tools/Tools+ supports the following radiometric file formats:

- Flir Systems radiometric *.jpg.
- Flir Systems radiometric *.img.
- Flir Systems radiometric *.fff.
- Flir Systems radiometric *.seq (video files).

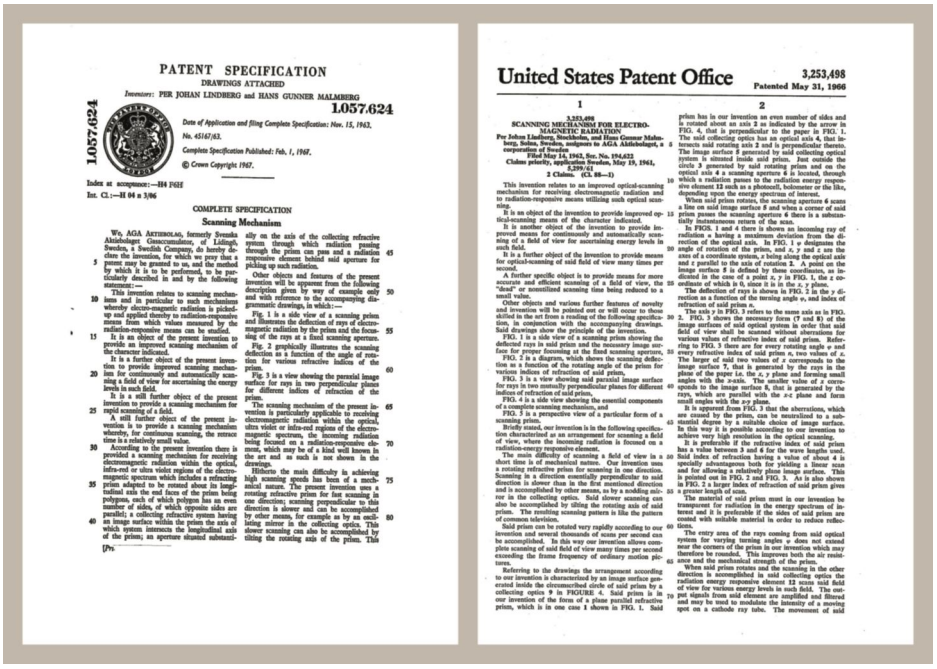
21.3 Non-radiometric file formats

Flir Tools/Tools+ supports the following non-radiometric file formats:

- *.jpg.
- *.mp4 (video files).
- *.avi (video files).
- *.pdf (reports and imagesheets).
- *.docx (as reports).

About Flir Systems

Flir Systems was established in 1978 to pioneer the development of high-performance infrared imaging systems, and is the world leader in the design, manufacture, and marketing of thermal imaging systems for a wide variety of commercial, industrial, and government applications. Today, Flir Systems embraces five major companies with outstanding achievements in infrared technology since 1958—the Swedish AGEMA Infrared Systems (formerly AGA Infrared Systems), the three United States companies Indigo Systems, FSI, and Inframetrics, and the French company Cedip. In November 2007, Extech Instruments was acquired by Flir Systems.



PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventors: PER JOHAN LINDBERG and HANS GUNNER MALMBERG

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Complete Specification Published: Feb. 1, 1967.

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Index at acceptance:—H4 F6H

Int. Cl.:—H 04 n 3/06

COMPLETE SPECIFICATION

Scanning Mechanism

We, AGA AKTIEBOLAG, formerly Svenska Aktiebolaget Gasaccumulator, of Lidingö, Sweden, a Swedish Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to scanning mechanisms and in particular to such mechanisms whereby electro-magnetic radiation is picked-up and applied thereby to radiation-responsive means from which values measured by the radiation-responsive means can be studied.

It is an object of the present invention to provide an improved scanning mechanism of the character indicated.

It is a further object of the present invention to provide improved scanning mechanism for continuously and automatically scanning a field of view for ascertaining the energy levels in such field.

It is a still further object of the present invention to provide a scanning mechanism for rapid scanning of a field.

A still further object of the present invention is to provide a scanning mechanism whereby, for continuous scanning, the retrace time is a relatively small value.

According to the present invention there is provided a scanning mechanism for receiving electromagnetic radiation within the optical, infra-red or ultra violet regions of the electromagnetic spectrum which includes a refracting prism adapted to be rotated about its longitudinal axis the end faces of the prism being polygons, each of which polygon has an even number of sides, of which opposite sides are parallel; a collecting refractive system having an image surface within the prism the axis of which system intersects the longitudinal axis of the prism; an aperture situated substantially on the axis of the collecting refractive system through which radiation passing through the prism can pass and a radiation responsive element behind said aperture for picking up such radiation.

Other objects and features of the present invention will be apparent from the following description given by way of example only and with reference to the accompanying diagrammatic drawings, in which:—

Fig. 1 is a side view of a scanning prism and illustrates the deflection of rays of electromagnetic radiation by the prism and the focussing of the rays at a fixed scanning aperture.

Fig. 2 graphically illustrates the scanning deflection as a function of the angle of rotation for various refractive indices of the prism.

Fig. 3 is a view showing the parallel image surface for rays in two perpendicular planes for different indices of refraction of the prism.

The scanning mechanism of the present invention is particularly applicable to receiving electromagnetic radiation within the optical, ultra violet or infra-red regions of the electromagnetic spectrum, the incoming radiation being focused on a radiation-responsive element, which may be of a kind well known in the art and as such is not shown in the drawings.

Hitherto the main difficulty in achieving high scanning speeds has been of a mechanical nature. The present invention uses a rotating refractive prism for fast scanning in one direction; scanning perpendicular to this direction is slower and can be accomplished by other means, for example as by an oscillating mirror in the collecting optics. This slower scanning can also be accomplished by tilting the rotating axis of the prism. This

[Pto

United States Patent Office 3,253,498 Patented May 31, 1966

1 2

3,253,498

SCANNING MECHANISM FOR ELECTRO-MAGNETIC RADIATION

Per Johan Lindberg, Stockholm, and Hans Gunnar Malmberg, Solna, Sweden, assignors to AGA Aktiebolaget, a corporation of Sweden

Filed May 15, 1963, Ser. No. 194,622

Claims priority, application Sweden, May 19, 1961, 5,399/61

2 Claims. (Cl. 88—1)

This invention relates to an improved optical-scanning mechanism for receiving electromagnetic radiation and to radiation-responsive means utilizing such optical scanning.

It is an object of the invention to provide improved optical-scanning means of the character indicated.

It is another object of the invention to provide improved means for continuously and automatically scanning of a field of view for ascertaining energy levels in such field.

It is a further object of the invention to provide means for optical-scanning of said field of view many times per second.

A further specific object is to provide means for more accurate and efficient scanning of a field of view, the "dead" or nonutilized scanning time being reduced to a small value.

Other objects and various further features of novelty and invention will be pointed out or will occur to those skilled in the art from a reading of the following specification, in conjunction with the accompanying drawings. Said drawings show the principle of the invention.

FIG. 1 is a side view of a scanning prism showing the deflected rays in said prism and the necessary image surface for proper focussing at the fixed scanning aperture, the

FIG. 2 is a diagram, which shows the scanning deflection as a function of the rotating angle of the prism for various indices of refraction of said prism,

FIG. 3 is a view showing said parallel image surface for rays in two mutually perpendicular planes for different indices of refraction of said prism,

FIG. 4 is a side view showing the essential components of a complete scanning mechanism, and

FIG. 5 is a perspective view of a particular form of a scanning prism.

Briefly stated, our invention is in the following specification characterized as an arrangement for scanning a field of view, where the incoming radiation is focused on a radiation-energy responsive element.

The main difficulty of scanning a field of view in a short time is of mechanical nature. Our invention uses a rotating refractive prism for scanning in one direction. Scanning in a direction essentially perpendicular to said direction is slower than in the first mentioned direction and is accomplished by other means, as by a nodding mirror in the collecting optics. Said slower scanning can also be accomplished by tilting the rotating axis of said prism. The resulting scanning pattern is like the pattern of common television.

Said prism can be rotated very rapidly according to our invention and several thousands of scans per second can be accomplished. In this way our invention allows complete scanning of said field of view many times per second exceeding the frame frequency of ordinary motion pictures.

Referring to the drawings the arrangement according to our invention is characterized by an image surface generated inside the circumscribed circle of said prism by a collecting optics 9 in FIGURE 4. Said prism is in our invention of the form of a plane parallel refractive prism, which is in one case 1 shown in FIG. 1. Said prism has in our invention an even number of sides and is rotated about an axis 2 as indicated by the arrow in FIG. 4, that is perpendicular to the paper in FIG. 1. The said collecting optics has an optical axis 4, that intersects said rotating axis 2 and is perpendicular thereto. The image surface 8 generated by said collecting optical system is situated inside said prism. Just outside the circle 3 generated by said rotating prism and on the optical axis 4 a scanning aperture 6 is located, through which a radiation passes to the radiation energy responsive element 12 such as a photocell, bolometer or the like, depending upon the energy spectrum of interest.

When said prism rotates, the scanning aperture 6 scans a line on said image surface 8 and when a corner of said prism passes the scanning aperture 6 there is a substantially instantaneous return of the scan.

In FIGS. 1 and 4 there is shown an incoming ray of radiation a having a maximum deviation from the direction of the optical axis. In FIG. 1 φ designates the angle of rotation of the prism, and x, y and z are the axes of a coordinate system, x being along the optical axis and z parallel to the axis of rotation 2. A point on the image surface 8 is defined by these coordinates, as indicated in the case of a point x, y in FIG. 1, the z coordinate of which is 0, since it is in the x, y plane.

The deflection of rays is shown in FIG. 2 in the y direction as a function of the turning angle φ, and index of refraction of said prism n.

The axis y in FIG. 3 refers to the same axis as in FIG. 2. FIG. 3 shows the necessary form (? and R) of the image surfaces of said optical system in order that said field of view shall be scanned without aberrations for various values of refractive index of said prism. Referring to FIG. 3 there are for every rotating angle φ and every refractive index of said prism n, two values of x. The larger of said two values of x corresponds to the image surface 7, that is generated by the rays in the plane of the paper i.e. the x, y plane and forming small angles with the y-axis. The smaller value of x corresponds to the image surface 8, that is generated by the rays, which are parallel with the x-z plane and form small angles with the x-y plane.

It is apparent from FIG. 3 that the aberrations, which are caused by the prism, can be neutralized to a substantial degree by a suitable choice of image surface. In this way it is possible according to our invention to achieve very high resolution in the optical scanning.

It is preferable if the refractive index of said prism has a value between 3 and 6 for the wave lengths used. Said value of refraction having a value of about 4 is specially advantageous both for yielding a linear scan and for allowing a relatively plane image surface. This is pointed out in FIG. 2 and FIG. 3. As is also shown in FIG. 2 a larger index of refraction of said prism gives a greater length of scan.

The material of said prism must in our invention be transparent for radiation in the energy spectrum of interest and it is preferable if the sides of said prism are coated with suitable material in order to reduce reflections.

The entry area of the rays coming from said optical system for varying turning angles φ does not extend near the corners of the prism in our invention which may therefore be rounded. This improves both the air resistance and the mechanical strength of the prism.

When said prism rotates and the scanning in the other direction is accomplished in said collecting optics the radiation energy responsive element 12 scans said field of view for various energy levels in such field. The output signals from said element are amplified and filtered and may be used to modulate the intensity of a moving spot on a cathode ray tube. The movement of said

Figure 22.1 Patent documents from the early 1960s

The company has sold more than 234,000 infrared cameras worldwide for applications such as predictive maintenance, R & D, non-destructive testing, process control and automation, and machine vision, among many others.

Flir Systems has three manufacturing plants in the United States (Portland, OR, Boston, MA, Santa Barbara, CA) and one in Sweden (Stockholm). Since 2007 there is also a manufacturing plant in Tallinn, Estonia. Direct sales offices in Belgium, Brazil, China, France, Germany, Great Britain, Hong Kong, Italy, Japan, Korea, Sweden, and the USA —together with a worldwide network of agents and distributors—support our international customer base.

Flir Systems is at the forefront of innovation in the infrared camera industry. We anticipate market demand by constantly improving our existing cameras and developing new ones. The company has set milestones in product design and development such as the introduction of the first battery-operated portable camera for industrial inspections, and the first uncooled infrared camera, to mention just two innovations.

Figure 22.2 LEFT: Thermovision Model 661 from 1969. The camera weighed approximately 25 kg (55 lb.), the oscilloscope 20 kg (44 lb.), and the tripod 15 kg (33 lb.). The operator also needed a 220 VAC generator set, and a 10 L (2.6 US gallon) jar with liquid nitrogen. To the left of the oscilloscope the Polaroid attachment (6 kg/13 lb.) can be seen. RIGHT: Flir i7 from 2012. Weight: 0.34 kg (0.75 lb.), including the battery.

Flir Systems manufactures all vital mechanical and electronic components of the camera systems itself. From detector design and manufacturing, to lenses and system electronics, to final testing and calibration, all production steps are carried out and supervised by our own engineers. The in-depth expertise of these infrared specialists ensures the accuracy and reliability of all vital components that are assembled into your infrared camera.

22.1 More than just an infrared camera

At Flir Systems we recognize that our job is to go beyond just producing the best infrared camera systems. We are committed to enabling all users of our infrared camera systems to work more productively by providing them with the most powerful camera–software combination. Especially tailored software for predictive maintenance, R & D, and process monitoring is developed in-house. Most software is available in a wide variety of languages.

We support all our infrared cameras with a wide variety of accessories to adapt your equipment to the most demanding infrared applications.

22.2 Sharing our knowledge

Although our cameras are designed to be very user-friendly, there is a lot more to thermography than just knowing how to handle a camera. Therefore, Flir Systems has founded the Infrared Training Center (ITC), a separate business unit, that provides certified training courses. Attending one of the ITC courses will give you a truly hands-on learning experience.

The staff of the ITC are also there to provide you with any application support you may need in putting infrared theory into practice.

22.3 Supporting our customers

Flir Systems operates a worldwide service network to keep your camera running at all times. If you discover a problem with your camera, local service centers have all the equipment and expertise to solve it within the shortest possible time. Therefore, there is no need to send your camera to the other side of the world or to talk to someone who does not speak your language.

22.4 A few images from our facilities

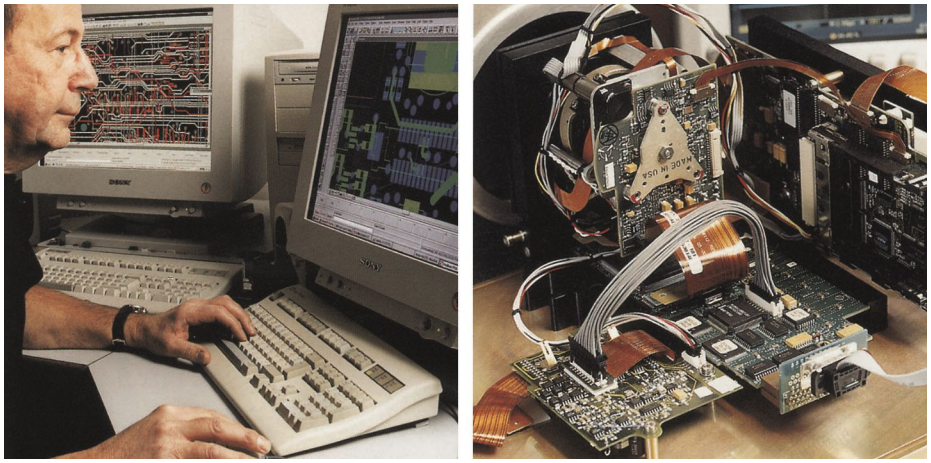

Figure 22.3 LEFT: Development of system electronics; RIGHT: Testing of an FPA detector

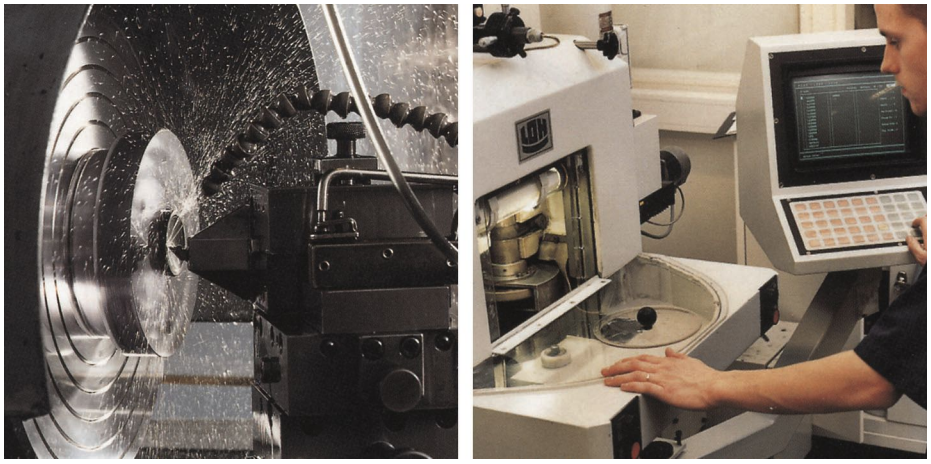

Figure 22.4 LEFT: Diamond turning machine; RIGHT: Lens polishing

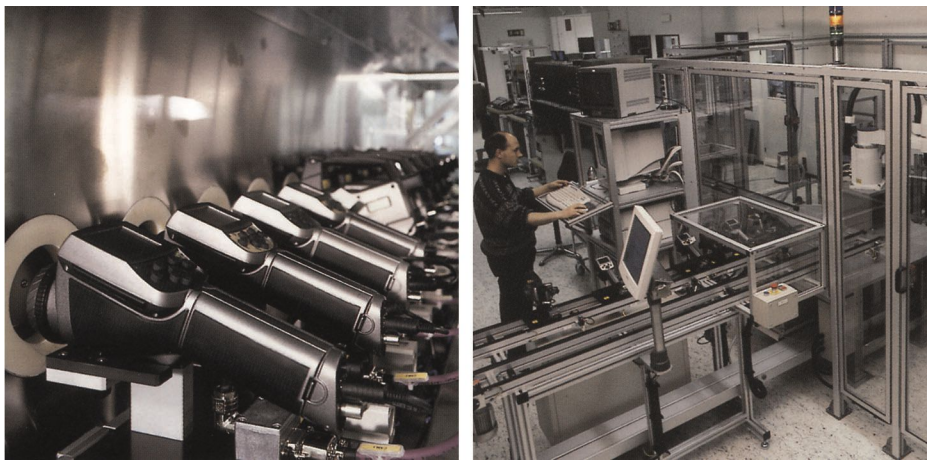

Figure 22.5 LEFT: Testing of infrared cameras in the climatic chamber; RIGHT: Robot used for camera testing and calibration

23 Glossary

absorption (absorption factor)	The amount of radiation absorbed by an object relative to the received radiation. A number between 0 and 1.
atmosphere	The gases between the object being measured and the camera, normally air.
autoadjust	A function making a camera perform an internal image correction.
autopalette	The IR image is shown with an uneven spread of colors, displaying cold objects as well as hot ones at the same time.
blackbody	Totally non-reflective object. All its radiation is due to its own temperature.
blackbody radiator	An IR radiating equipment with blackbody properties used to calibrate IR cameras.
calculated atmospheric transmission	A transmission value computed from the temperature, the relative humidity of air and the distance to the object.
cavity radiator	A bottle shaped radiator with an absorbing inside, viewed through the bottleneck.
color temperature	The temperature for which the color of a blackbody matches a specific color.
conduction	The process that makes heat diffuse into a material.
continuous adjust	A function that adjusts the image. The function works all the time, continuously adjusting brightness and contrast according to the image content.
convection	Convection is a heat transfer mode where a fluid is brought into motion, either by gravity or another force, thereby transferring heat from one place to another.
dual isotherm	An isotherm with two color bands, instead of one.
emissivity (emissivity factor)	The amount of radiation coming from an object, compared to that of a blackbody. A number between 0 and 1.
emittance	Amount of energy emitted from an object per unit of time and area (W/m^2)
environment	Objects and gases that emit radiation towards the object being measured.
estimated atmospheric transmission	A transmission value, supplied by a user, replacing a calculated one
external optics	Extra lenses, filters, heat shields etc. that can be put between the camera and the object being measured.
filter	A material transparent only to some of the infrared wavelengths.
FOV	Field of view: The horizontal angle that can be viewed through an IR lens.
FPA	Focal plane array: A type of IR detector.
graybody	An object that emits a fixed fraction of the amount of energy of a blackbody for each wavelength.
IFOV	Instantaneous field of view: A measure of the geometrical resolution of an IR camera.

image correction (internal or external)	A way of compensating for sensitivity differences in various parts of live images and also of stabilizing the camera.
infrared	Non-visible radiation, having a wavelength from about 2–13 µm.
IR	infrared
isotherm	A function highlighting those parts of an image that fall above, below or between one or more temperature intervals.
isothermal cavity	A bottle-shaped radiator with a uniform temperature viewed through the bottleneck.
Laser LocatIR	An electrically powered light source on the camera that emits laser radiation in a thin, concentrated beam to point at certain parts of the object in front of the camera.
laser pointer	An electrically powered light source on the camera that emits laser radiation in a thin, concentrated beam to point at certain parts of the object in front of the camera.
level	The center value of the temperature scale, usually expressed as a signal value.
manual adjust	A way to adjust the image by manually changing certain parameters.
NETD	Noise equivalent temperature difference. A measure of the image noise level of an IR camera.
noise	Undesired small disturbance in the infrared image
object parameters	A set of values describing the circumstances under which the measurement of an object was made, and the object itself (such as emissivity, reflected apparent temperature, distance etc.)
object signal	A non-calibrated value related to the amount of radiation received by the camera from the object.
palette	The set of colors used to display an IR image.
pixel	Stands for *picture element*. One single spot in an image.
radiance	Amount of energy emitted from an object per unit of time, area and angle ($W/m^2/sr$)
radiant power	Amount of energy emitted from an object per unit of time (W)
radiation	The process by which electromagnetic energy, is emitted by an object or a gas.
radiator	A piece of IR radiating equipment.
range	The current overall temperature measurement limitation of an IR camera. Cameras can have several ranges. Expressed as two blackbody temperatures that limit the current calibration.
reference temperature	A temperature which the ordinary measured values can be compared with.
reflection	The amount of radiation reflected by an object relative to the received radiation. A number between 0 and 1.
relative humidity	Relative humidity represents the ratio between the current water vapour mass in the air and the maximum it may contain in saturation conditions.
saturation color	The areas that contain temperatures outside the present level/span settings are colored with the saturation colors. The saturation colors contain an ‘overflow’ color and an ‘underflow’ color. There is also a third red saturation color that marks everything saturated by the detector indicating that the range should probably be changed.

span	The interval of the temperature scale, usually expressed as a signal value.
spectral (radiant) emittance	Amount of energy emitted from an object per unit of time, area and wavelength ($W/m^2/\mu m$)
temperature difference, or difference of temperature.	A value which is the result of a subtraction between two temperature values.
temperature range	The current overall temperature measurement limitation of an IR camera. Cameras can have several ranges. Expressed as two blackbody temperatures that limit the current calibration.
temperature scale	The way in which an IR image currently is displayed. Expressed as two temperature values limiting the colors.
thermogram	infrared image
transmission (or transmittance) factor	Gases and materials can be more or less transparent. Transmission is the amount of IR radiation passing through them. A number between 0 and 1.
transparent isotherm	An isotherm showing a linear spread of colors, instead of covering the highlighted parts of the image.
visual	Refers to the video mode of a IR camera, as opposed to the normal, thermographic mode. When a camera is in video mode it captures ordinary video images, while thermographic images are captured when the camera is in IR mode.

24 Thermographic measurement techniques

24.1 Introduction

An infrared camera measures and images the emitted infrared radiation from an object. The fact that radiation is a function of object surface temperature makes it possible for the camera to calculate and display this temperature.

However, the radiation measured by the camera does not only depend on the temperature of the object but is also a function of the emissivity. Radiation also originates from the surroundings and is reflected in the object. The radiation from the object and the reflected radiation will also be influenced by the absorption of the atmosphere.

To measure temperature accurately, it is therefore necessary to compensate for the effects of a number of different radiation sources. This is done on-line automatically by the camera. The following object parameters must, however, be supplied for the camera:

- The emissivity of the object
- The reflected apparent temperature
- The distance between the object and the camera
- The relative humidity
- Temperature of the atmosphere

24.2 Emissivity

The most important object parameter to set correctly is the emissivity which, in short, is a measure of how much radiation is emitted from the object, compared to that from a perfect blackbody of the same temperature.

Normally, object materials and surface treatments exhibit emissivity ranging from approximately 0.1 to 0.95. A highly polished (mirror) surface falls below 0.1, while an oxidized or painted surface has a higher emissivity. Oil-based paint, regardless of color in the visible spectrum, has an emissivity over 0.9 in the infrared. Human skin exhibits an emissivity 0.97 to 0.98.

Non-oxidized metals represent an extreme case of perfect opacity and high reflexivity, which does not vary greatly with wavelength. Consequently, the emissivity of metals is low – only increasing with temperature. For non-metals, emissivity tends to be high, and decreases with temperature.

24.2.1 Finding the emissivity of a sample

24.2.1.1 Step 1: Determining reflected apparent temperature

Use one of the following two methods to determine reflected apparent temperature:

24.2.1.1.1 Method 1: Direct method

Follow this procedure:

1. Look for possible reflection sources, considering that the incident angle = reflection angle (a = b).

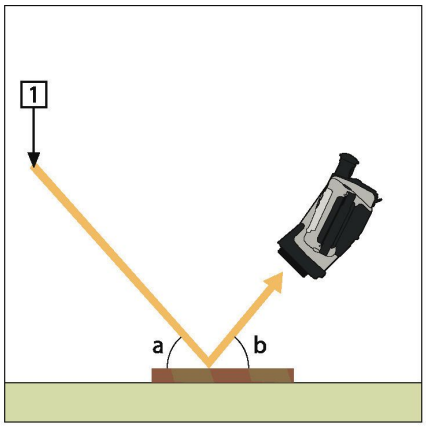

Figure 24.1 1 = Reflection source

2. If the reflection source is a spot source, modify the source by obstructing it using a piece if cardboard.

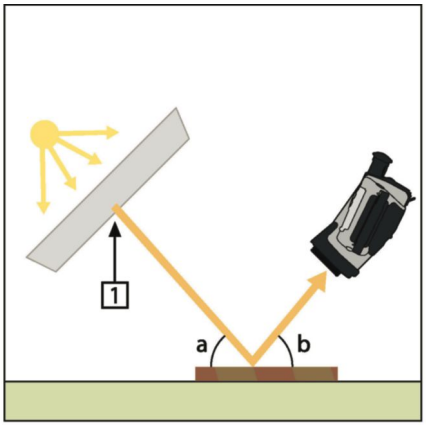

Figure 24.2 1 = Reflection source

3. Measure the radiation intensity (= apparent temperature) from the reflecting source using the following settings:
   - Emissivity: 1.0
   - D_{obj}: 0

   You can measure the radiation intensity using one of the following two methods:

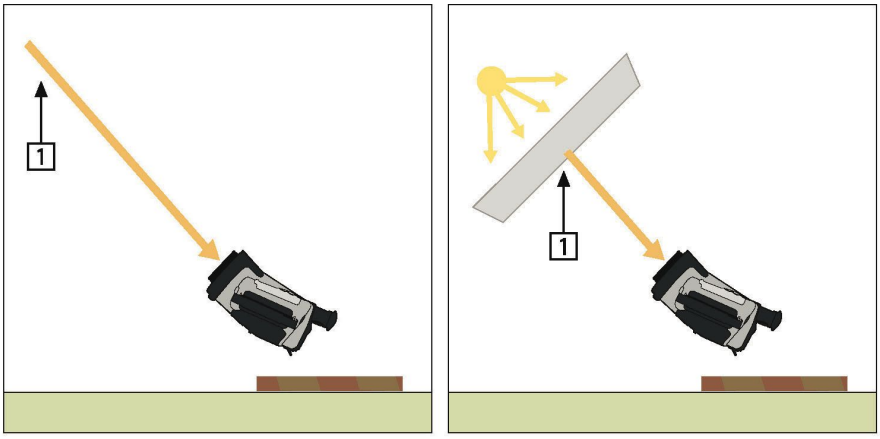

Figure 24.3 1 = Reflection source

Note
Using a thermocouple to measure reflected apparent temperature is not recommended for two important reasons:
- A thermocouple does not measure radiation intensity
- A thermocouple requires a very good thermal contact to the surface, usually by gluing and covering the sensor by a thermal isolator.

24.2.1.1.2 Method 2: Reflector method

Follow this procedure:

1. Crumble up a large piece of aluminum foil.
2. Uncrumble the aluminum foil and attach it to a piece of cardboard of the same size.
3. Put the piece of cardboard in front of the object you want to measure. Make sure that the side with aluminum foil points to the camera.
4. Set the emissivity to 1.0.
5. Measure the apparent temperature of the aluminum foil and write it down.

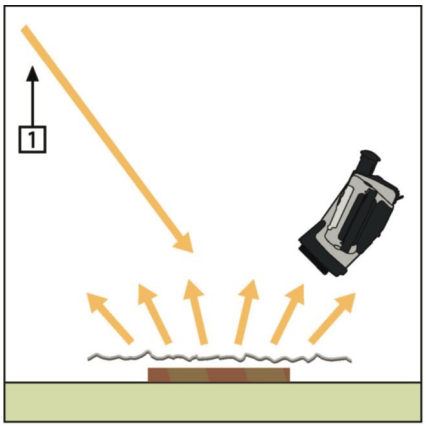

Figure 24.4 Measuring the apparent temperature of the aluminum foil.

24.2.1.2 Step 2: Determining the emissivity

Follow this procedure:

1. Select a place to put the sample.
2. Determine and set reflected apparent temperature according to the previous procedure.
3. Put a piece of electrical tape with known high emissivity on the sample.
4. Heat the sample at least 20 K above room temperature. Heating must be reasonably even.
5. Focus and auto-adjust the camera, and freeze the image.
6. Adjust *Level* and *Span* for best image brightness and contrast.
7. Set emissivity to that of the tape (usually 0.97).
8. Measure the temperature of the tape using one of the following measurement functions:
   - *Isotherm* (helps you to determine both the temperature and how evenly you have heated the sample)
   - *Spot* (simpler)
   - *Box Avg* (good for surfaces with varying emissivity).
9. Write down the temperature.
10. Move your measurement function to the sample surface.
11. Change the emissivity setting until you read the same temperature as your previous measurement.
12. Write down the emissivity.

Note

- Avoid forced convection
- Look for a thermally stable surrounding that will not generate spot reflections
- Use high quality tape that you know is not transparent, and has a high emissivity you are certain of
- This method assumes that the temperature of your tape and the sample surface are the same. If they are not, your emissivity measurement will be wrong.

24.3 Reflected apparent temperature

This parameter is used to compensate for the radiation reflected in the object. If the emissivity is low and the object temperature relatively far from that of the reflected it will be important to set and compensate for the reflected apparent temperature correctly.

24.4 Distance

The distance is the distance between the object and the front lens of the camera. This parameter is used to compensate for the following two facts:

- That radiation from the target is absorbed by the atmosphere between the object and the camera.
- That radiation from the atmosphere itself is detected by the camera.

24.5 Relative humidity

The camera can also compensate for the fact that the transmittance is also dependent on the relative humidity of the atmosphere. To do this set the relative humidity to the correct value. For short distances and normal humidity the relative humidity can normally be left at a default value of 50%.

24.6 Other parameters

In addition, some cameras and analysis programs from Flir Systems allow you to compensate for the following parameters:

- Atmospheric temperature – *i.e.* the temperature of the atmosphere between the camera and the target
- External optics temperature – *i.e.* the temperature of any external lenses or windows used in front of the camera

- External optics transmittance – *i.e.* the transmission of any external lenses or windows used in front of the camera

25 History of infrared technology

Before the year 1800, the existence of the infrared portion of the electromagnetic spectrum wasn't even suspected. The original significance of the infrared spectrum, or simply ‘the infrared’ as it is often called, as a form of heat radiation is perhaps less obvious today than it was at the time of its discovery by Herschel in 1800.

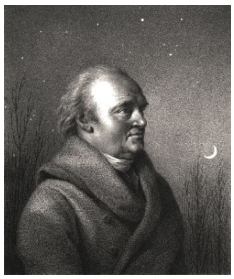

Figure 25.1 Sir William Herschel (1738–1822)

The discovery was made accidentally during the search for a new optical material. Sir William Herschel – Royal Astronomer to King George III of England, and already famous for his discovery of the planet Uranus – was searching for an optical filter material to reduce the brightness of the sun’s image in telescopes during solar observations. While testing different samples of colored glass which gave similar reductions in brightness he was intrigued to find that some of the samples passed very little of the sun’s heat, while others passed so much heat that he risked eye damage after only a few seconds’ observation.

Herschel was soon convinced of the necessity of setting up a systematic experiment, with the objective of finding a single material that would give the desired reduction in brightness as well as the maximum reduction in heat. He began the experiment by actually repeating Newton’s prism experiment, but looking for the heating effect rather than the visual distribution of intensity in the spectrum. He first blackened the bulb of a sensitive mercury-in-glass thermometer with ink, and with this as his radiation detector he proceeded to test the heating effect of the various colors of the spectrum formed on the top of a table by passing sunlight through a glass prism. Other thermometers, placed outside the sun’s rays, served as controls.

As the blackened thermometer was moved slowly along the colors of the spectrum, the temperature readings showed a steady increase from the violet end to the red end. This was not entirely unexpected, since the Italian researcher, Landriani, in a similar experiment in 1777 had observed much the same effect. It was Herschel, however, who was the first to recognize that there must be a point where the heating effect reaches a maximum, and that measurements confined to the visible portion of the spectrum failed to locate this point.

Figure 25.2 Marsilio Landriani (1746–1815)

Moving the thermometer into the dark region beyond the red end of the spectrum, Herschel confirmed that the heating continued to increase. The maximum point, when he found it, lay well beyond the red end – in what is known today as the ‘infrared wavelengths’.

When Herschel revealed his discovery, he referred to this new portion of the electromagnetic spectrum as the ‘thermometrical spectrum’. The radiation itself he sometimes referred to as ‘dark heat’, or simply ‘the invisible rays’. Ironically, and contrary to popular opinion, it wasn't Herschel who originated the term ‘infrared’. The word only began to appear in print around 75 years later, and it is still unclear who should receive credit as the originator.

Herschel’s use of glass in the prism of his original experiment led to some early controversies with his contemporaries about the actual existence of the infrared wavelengths. Different investigators, in attempting to confirm his work, used various types of glass indiscriminately, having different transparencies in the infrared. Through his later experiments, Herschel was aware of the limited transparency of glass to the newly-discovered thermal radiation, and he was forced to conclude that optics for the infrared would probably be doomed to the use of reflective elements exclusively (i.e. plane and curved mirrors). Fortunately, this proved to be true only until 1830, when the Italian investigator, Melloni, made his great discovery that naturally occurring rock salt (NaCl) – which was available in large enough natural crystals to be made into lenses and prisms – is remarkably transparent to the infrared. The result was that rock salt became the principal infrared optical material, and remained so for the next hundred years, until the art of synthetic crystal growing was mastered in the 1930’s.

Figure 25.3 Macedonio Melloni (1798–1854)

Thermometers, as radiation detectors, remained unchallenged until 1829, the year Nobili invented the thermocouple. (Herschel’s own thermometer could be read to 0.2 °C (0.036 °F), and later models were able to be read to 0.05 °C (0.09 °F)). Then a breakthrough occurred; Melloni connected a number of thermocouples in series to form the first thermopile. The new device was at least 40 times as sensitive as the best thermometer of the day for detecting heat radiation – capable of detecting the heat from a person standing three meters away.

The first so-called ‘heat-picture’ became possible in 1840, the result of work by Sir John Herschel, son of the discoverer of the infrared and a famous astronomer in his own right. Based upon the differential evaporation of a thin film of oil when exposed to a heat pattern focused upon it, the thermal image could be seen by reflected light where the interference effects of the oil film made the image visible to the eye. Sir John also managed to obtain a primitive record of the thermal image on paper, which he called a ‘thermograph’.

Figure 25.4 Samuel P. Langley (1834–1906)

The improvement of infrared-detector sensitivity progressed slowly. Another major breakthrough, made by Langley in 1880, was the invention of the bolometer. This consisted of a thin blackened strip of platinum connected in one arm of a Wheatstone bridge circuit upon which the infrared radiation was focused and to which a sensitive galvanometer responded. This instrument is said to have been able to detect the heat from a cow at a distance of 400 meters.

An English scientist, Sir James Dewar, first introduced the use of liquefied gases as cooling agents (such as liquid nitrogen with a temperature of -196 °C (-320.8 °F)) in low temperature research. In 1892 he invented a unique vacuum insulating container in which it is possible to store liquefied gases for entire days. The common ‘thermos bottle’, used for storing hot and cold drinks, is based upon his invention.

Between the years 1900 and 1920, the inventors of the world ‘discovered’ the infrared. Many patents were issued for devices to detect personnel, artillery, aircraft, ships – and even icebergs. The first operating systems, in the modern sense, began to be developed during the 1914–18 war, when both sides had research programs devoted to the military exploitation of the infrared. These programs included experimental systems for enemy intrusion/detection, remote temperature sensing, secure communications, and ‘flying torpedo’ guidance. An infrared search system tested during this period was able to detect an approaching airplane at a distance of 1.5 km (0.94 miles), or a person more than 300 meters (984 ft.) away.

The most sensitive systems up to this time were all based upon variations of the bolometer idea, but the period between the two wars saw the development of two revolutionary new infrared detectors: the image converter and the photon detector. At first, the image converter received the greatest attention by the military, because it enabled an observer for the first time in history to literally ‘see in the dark’. However, the sensitivity of the image converter was limited to the near infrared wavelengths, and the most interesting military targets (i.e. enemy soldiers) had to be illuminated by infrared search beams. Since this involved the risk of giving away the observer’s position to a similarly-equipped enemy observer, it is understandable that military interest in the image converter eventually faded.

The tactical military disadvantages of so-called 'active’ (i.e. search beam-equipped) thermal imaging systems provided impetus following the 1939–45 war for extensive secret military infrared-research programs into the possibilities of developing ‘passive’ (no search beam) systems around the extremely sensitive photon detector. During this period, military secrecy regulations completely prevented disclosure of the status of infrared-imaging technology. This secrecy only began to be lifted in the middle of the 1950’s, and from that time adequate thermal-imaging devices finally began to be available to civilian science and industry.

26 Theory of thermography

26.1 Introduction

The subjects of infrared radiation and the related technique of thermography are still new to many who will use an infrared camera. In this section the theory behind thermography will be given.

26.2 The electromagnetic spectrum

The electromagnetic spectrum is divided arbitrarily into a number of wavelength regions, called *bands*, distinguished by the methods used to produce and detect the radiation. There is no fundamental difference between radiation in the different bands of the electromagnetic spectrum. They are all governed by the same laws and the only differences are those due to differences in wavelength.

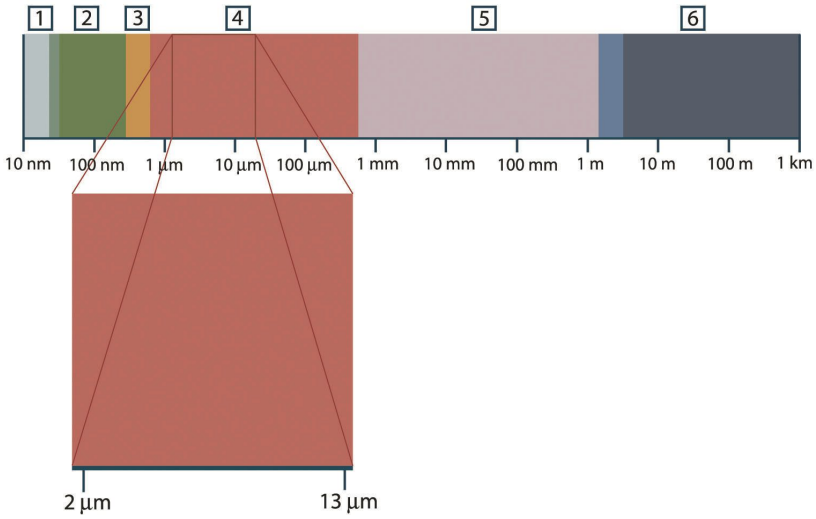

Figure 26.1 The electromagnetic spectrum. 1: X-ray; 2: UV; 3: Visible; 4: IR; 5: Microwaves; 6: Radiowaves.

Thermography makes use of the infrared spectral band. At the short-wavelength end the boundary lies at the limit of visual perception, in the deep red. At the long-wavelength end it merges with the microwave radio wavelengths, in the millimeter range.

The infrared band is often further subdivided into four smaller bands, the boundaries of which are also arbitrarily chosen. They include: the *near infrared* (0.75–3 µm), the *middle infrared* (3–6 µm), the *far infrared* (6–15 µm) and the *extreme infrared* (15–100 µm). Although the wavelengths are given in µm (micrometers), other units are often still used to measure wavelength in this spectral region, *e.g.* nanometer (nm) and Ångström (Å).

The relationships between the different wavelength measurements is:

$$10\ 000\ \text{Å} = 1\ 000\ \text{nm} = 1\ \mu = 1\ \mu\text{m}$$

26.3 Blackbody radiation

A blackbody is defined as an object which absorbs all radiation that impinges on it at any wavelength. The apparent misnomer *black* relating to an object emitting radiation is explained by Kirchhoff's Law (after *Gustav Robert Kirchhoff*, 1824–1887), which states that a body capable of absorbing all radiation at any wavelength is equally capable in the emission of radiation.

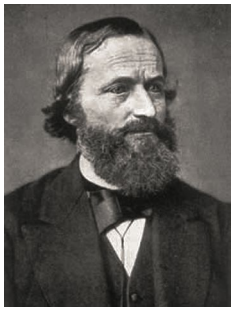

Figure 26.2 Gustav Robert Kirchhoff (1824–1887)

The construction of a blackbody source is, in principle, very simple. The radiation characteristics of an aperture in an isotherm cavity made of an opaque absorbing material represents almost exactly the properties of a blackbody. A practical application of the principle to the construction of a perfect absorber of radiation consists of a box that is light tight except for an aperture in one of the sides. Any radiation which then enters the hole is scattered and absorbed by repeated reflections so only an infinitesimal fraction can possibly escape. The blackness which is obtained at the aperture is nearly equal to a blackbody and almost perfect for all wavelengths.

By providing such an isothermal cavity with a suitable heater it becomes what is termed a *cavity radiator*. An isothermal cavity heated to a uniform temperature generates blackbody radiation, the characteristics of which are determined solely by the temperature of the cavity. Such cavity radiators are commonly used as sources of radiation in temperature reference standards in the laboratory for calibrating thermographic instruments, such as a Flir Systems camera for example.

If the temperature of blackbody radiation increases to more than 525°C (977°F), the source begins to be visible so that it appears to the eye no longer black. This is the incipient red heat temperature of the radiator, which then becomes orange or yellow as the temperature increases further. In fact, the definition of the so-called *color temperature* of an object is the temperature to which a blackbody would have to be heated to have the same appearance.

Now consider three expressions that describe the radiation emitted from a blackbody.

26.3.1 Planck's law

Figure 26.3 Max Planck (1858–1947)

Max Planck (1858–1947) was able to describe the spectral distribution of the radiation from a blackbody by means of the following formula:

$$W_{\lambda b} = \frac{2\pi hc^2}{\lambda^5 \left(e^{hc/\lambda kT} - 1 \right)} \times 10^{-6} [Watt / m^2, \mu m]$$

where:

$W_{\lambda b}$	Blackbody spectral radiant emittance at wavelength λ.
c	Velocity of light = 3×10^8 m/s
h	Planck's constant = 6.6×10^{-34} Joule sec.
k	Boltzmann's constant = 1.4×10^{-23} Joule/K.
T	Absolute temperature (K) of a blackbody.
λ	Wavelength (µm).

Note
The factor 10^{-6} is used since spectral emittance in the curves is expressed in Watt/m², µm.

Planck's formula, when plotted graphically for various temperatures, produces a family of curves. Following any particular Planck curve, the spectral emittance is zero at λ = 0, then increases rapidly to a maximum at a wavelength λ_{max} and after passing it approaches zero again at very long wavelengths. The higher the temperature, the shorter the wavelength at which maximum occurs.

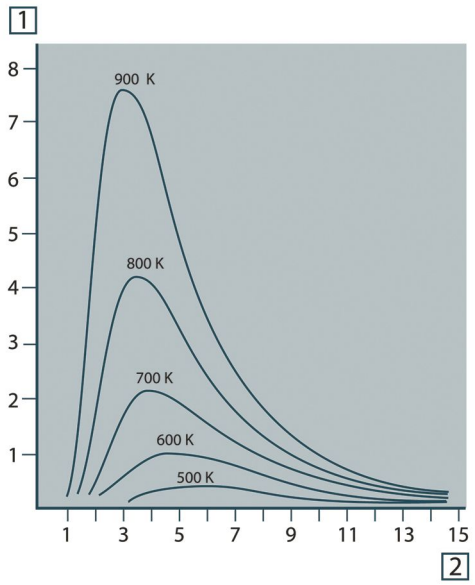

Figure 26.4 Blackbody spectral radiant emittance according to Planck's law, plotted for various absolute temperatures. 1: Spectral radiant emittance (W/cm² × 10³(µm)); 2: Wavelength (µm)

26.3.2 Wien's displacement law

By differentiating Planck's formula with respect to λ, and finding the maximum, we have:

$$\lambda_{\max} = \frac{2898}{T}[\mu m]$$

This is Wien's formula (after *Wilhelm Wien*, 1864–1928), which expresses mathematically the common observation that colors vary from red to orange or yellow as the temperature of a thermal radiator increases. The wavelength of the color is the same as the wavelength calculated for λ_{max}. A good approximation of the value of λ_{max} for a given blackbody temperature is obtained by applying the rule-of-thumb 3 000/T µm. Thus, a very hot star such as Sirius (11 000 K), emitting bluish-white light, radiates with the peak of spectral radiant emittance occurring within the invisible ultraviolet spectrum, at wavelength 0.27 µm.

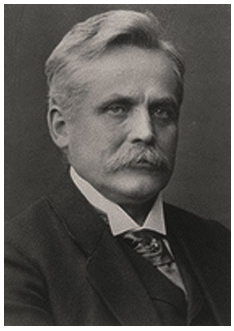

Figure 26.5 Wilhelm Wien (1864–1928)

The sun (approx. 6 000 K) emits yellow light, peaking at about 0.5 µm in the middle of the visible light spectrum.

At room temperature (300 K) the peak of radiant emittance lies at 9.7 µm, in the far infrared, while at the temperature of liquid nitrogen (77 K) the maximum of the almost insignificant amount of radiant emittance occurs at 38 µm, in the extreme infrared wavelengths.

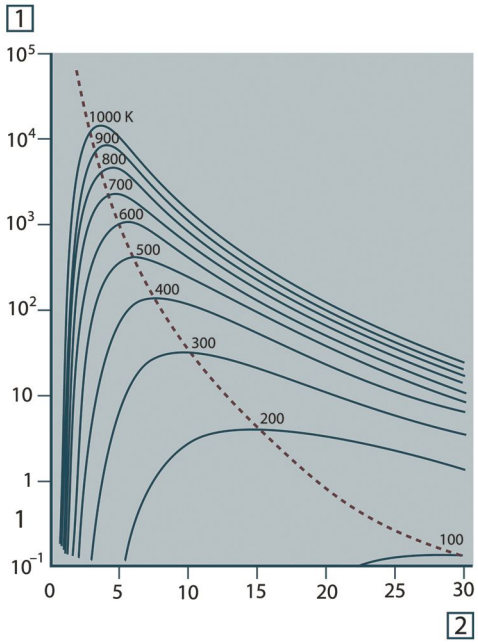

Figure 26.6 Planckian curves plotted on semi-log scales from 100 K to 1000 K. The dotted line represents the locus of maximum radiant emittance at each temperature as described by Wien's displacement law. 1: Spectral radiant emittance (W/cm² (µm)); 2: Wavelength (µm).

26.3.3 Stefan-Boltzmann's law

By integrating Planck's formula from $\lambda = 0$ to $\lambda = \infty$, we obtain the total radiant emittance (W_b) of a blackbody:

$$W_b = \sigma T^4 \ [\mathrm{Watt/m^2}]$$

This is the Stefan-Boltzmann formula (after *Josef Stefan*, 1835–1893, and *Ludwig Boltzmann*, 1844–1906), which states that the total emissive power of a blackbody is proportional to the fourth power of its absolute temperature. Graphically, W_b represents the area below the Planck curve for a particular temperature. It can be shown that the radiant emittance in the interval $\lambda = 0$ to λ_{max} is only 25% of the total, which represents about the amount of the sun's radiation which lies inside the visible light spectrum.

Figure 26.7 Josef Stefan (1835–1893), and Ludwig Boltzmann (1844–1906)

Using the Stefan-Boltzmann formula to calculate the power radiated by the human body, at a temperature of 300 K and an external surface area of approx. 2 m^2, we obtain 1 kW. This power loss could not be sustained if it were not for the compensating absorption of radiation from surrounding surfaces, at room temperatures which do not vary too drastically from the temperature of the body – or, of course, the addition of clothing.

26.3.4 Non-blackbody emitters

So far, only blackbody radiators and blackbody radiation have been discussed. However, real objects almost never comply with these laws over an extended wavelength region – although they may approach the blackbody behavior in certain spectral intervals. For example, a certain type of white paint may appear perfectly *white* in the visible light spectrum, but becomes distinctly *gray* at about 2 µm, and beyond 3 µm it is almost *black*.

There are three processes which can occur that prevent a real object from acting like a blackbody: a fraction of the incident radiation α may be absorbed, a fraction ρ may be reflected, and a fraction τ may be transmitted. Since all of these factors are more or less wavelength dependent, the subscript λ is used to imply the spectral dependence of their definitions. Thus:

- The spectral absorptance α_λ= the ratio of the spectral radiant power absorbed by an object to that incident upon it.
- The spectral reflectance ρ_λ = the ratio of the spectral radiant power reflected by an object to that incident upon it.
- The spectral transmittance τ_λ = the ratio of the spectral radiant power transmitted through an object to that incident upon it.

The sum of these three factors must always add up to the whole at any wavelength, so we have the relation:

$$\alpha_\lambda + \rho_\lambda + \tau_\lambda = 1$$

For opaque materials $\tau_\lambda = 0$ and the relation simplifies to:

$$\varepsilon_\lambda + \rho_\lambda = 1$$

Another factor, called the emissivity, is required to describe the fraction ε of the radiant emittance of a blackbody produced by an object at a specific temperature. Thus, we have the definition:

The spectral emissivity ε_λ= the ratio of the spectral radiant power from an object to that from a blackbody at the same temperature and wavelength.

Expressed mathematically, this can be written as the ratio of the spectral emittance of the object to that of a blackbody as follows:

$$\varepsilon_\lambda = \frac{W_{\lambda o}}{W_{\lambda b}}$$

Generally speaking, there are three types of radiation source, distinguished by the ways in which the spectral emittance of each varies with wavelength.

- A blackbody, for which $\varepsilon_\lambda = \varepsilon = 1$
- A graybody, for which $\varepsilon_\lambda = \varepsilon$ = constant less than 1

- A selective radiator, for which ε varies with wavelength

According to Kirchhoff's law, for any material the spectral emissivity and spectral absorptance of a body are equal at any specified temperature and wavelength. That is:

$$\varepsilon_\lambda = \alpha_\lambda$$

From this we obtain, for an opaque material (since $\alpha_\lambda + \rho_\lambda = 1$):

$$\varepsilon_\lambda + \rho_\lambda = 1$$

For highly polished materials ε_λ approaches zero, so that for a perfectly reflecting material (*i.e.* a perfect mirror) we have:

$$\rho_\lambda = 1$$

For a graybody radiator, the Stefan-Boltzmann formula becomes:

$$W = \varepsilon \sigma T^4 \, [\mathrm{Watt/m^2}]$$

This states that the total emissive power of a graybody is the same as a blackbody at the same temperature reduced in proportion to the value of ε from the graybody.

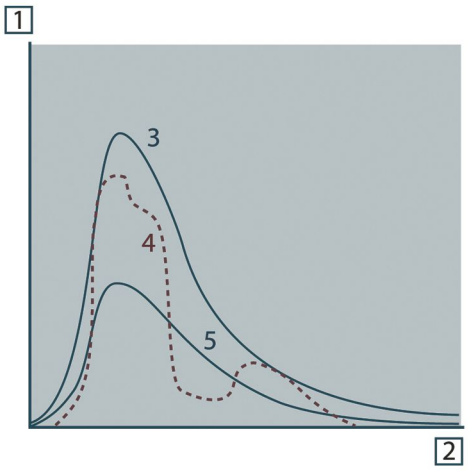

Figure 26.8 Spectral radiant emittance of three types of radiators. 1: Spectral radiant emittance; 2: Wavelength; 3: Blackbody; 4: Selective radiator; 5: Graybody.

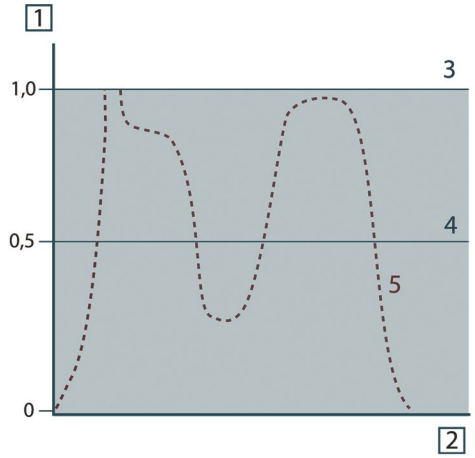

Figure 26.9 Spectral emissivity of three types of radiators. 1: Spectral emissivity; 2: Wavelength; 3: Blackbody; 4: Graybody; 5: Selective radiator.

26.4 Infrared semi-transparent materials

Consider now a non-metallic, semi-transparent body – let us say, in the form of a thick flat plate of plastic material. When the plate is heated, radiation generated within its volume must work its way toward the surfaces through the material in which it is partially absorbed. Moreover, when it arrives at the surface, some of it is reflected back into the interior. The back-reflected radiation is again partially absorbed, but some of it arrives at the other surface, through which most of it escapes; part of it is reflected back again. Although the progressive reflections become weaker and weaker they must all be added up when the total emittance of the plate is sought. When the resulting geometrical series is summed, the effective emissivity of a semi-transparent plate is obtained as:

$$\varepsilon_\lambda = \frac{(1-\rho_\lambda)(1-\tau_\lambda)}{1-\rho_\lambda\tau_\lambda}$$

When the plate becomes opaque this formula is reduced to the single formula:

$$\varepsilon_\lambda = 1-\rho_\lambda$$

This last relation is a particularly convenient one, because it is often easier to measure reflectance than to measure emissivity directly.

27 The measurement formula

As already mentioned, when viewing an object, the camera receives radiation not only from the object itself. It also collects radiation from the surroundings reflected via the object surface. Both these radiation contributions become attenuated to some extent by the atmosphere in the measurement path. To this comes a third radiation contribution from the atmosphere itself.

This description of the measurement situation, as illustrated in the figure below, is so far a fairly true description of the real conditions. What has been neglected could for instance be sun light scattering in the atmosphere or stray radiation from intense radiation sources outside the field of view. Such disturbances are difficult to quantify, however, in most cases they are fortunately small enough to be neglected. In case they are not negligible, the measurement configuration is likely to be such that the risk for disturbance is obvious, at least to a trained operator. It is then his responsibility to modify the measurement situation to avoid the disturbance e.g. by changing the viewing direction, shielding off intense radiation sources etc.

Accepting the description above, we can use the figure below to derive a formula for the calculation of the object temperature from the calibrated camera output.

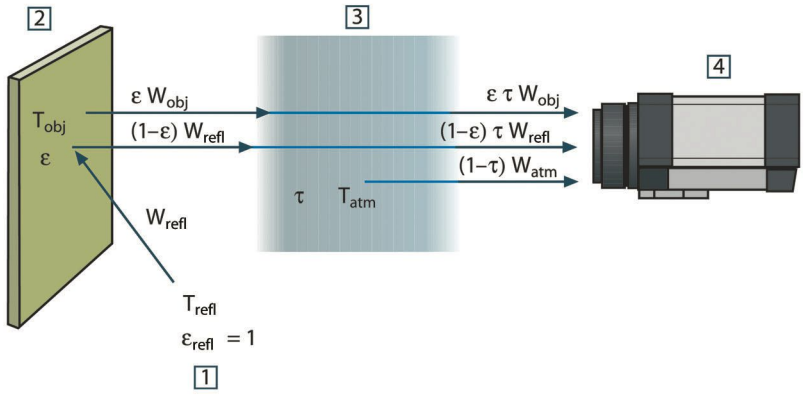

Figure 27.1 A schematic representation of the general thermographic measurement situation.1: Surroundings; 2: Object; 3: Atmosphere; 4: Camera

Assume that the received radiation power W from a blackbody source of temperature T_{source} on short distance generates a camera output signal U_{source} that is proportional to the power input (power linear camera). We can then write (Equation 1):

$$U_{source} = CW(T_{source})$$

or, with simplified notation:

$$U_{source} = CW_{source}$$

where C is a constant.

Should the source be a graybody with emittance ε, the received radiation would consequently be εW_{source}.

We are now ready to write the three collected radiation power terms:

1. *Emission from the object* = $\varepsilon\tau W_{obj}$, where ε is the emittance of the object and τ is the transmittance of the atmosphere. The object temperature is T_{obj}.

2. *Reflected emission from ambient sources* = $(1 - \varepsilon)\tau W_{refl}$, where $(1 - \varepsilon)$ is the reflectance of the object. The ambient sources have the temperature T_{refl}.
   It has here been assumed that the temperature T_{refl} is the same for all emitting surfaces within the halfsphere seen from a point on the object surface. This is of course sometimes a simplification of the true situation. It is, however, a necessary simplification in order to derive a workable formula, and T_{refl} can – at least theoretically – be given a value that represents an efficient temperature of a complex surrounding.

   Note also that we have assumed that the emittance for the surroundings = 1. This is correct in accordance with Kirchhoff's law: All radiation impinging on the surrounding surfaces will eventually be absorbed by the same surfaces. Thus the emittance = 1. (Note though that the latest discussion requires the complete sphere around the object to be considered.)
3. *Emission from the atmosphere* = $(1 - \tau)\tau W_{atm}$, where $(1 - \tau)$ is the emittance of the atmosphere. The temperature of the atmosphere is T_{atm}.

The total received radiation power can now be written (Equation 2):

$$W_{tot} = \varepsilon\tau W_{obj} + (1-\varepsilon)\tau W_{refl} + (1-\tau)W_{atm}$$

We multiply each term by the constant C of Equation 1 and replace the CW products by the corresponding U according to the same equation, and get (Equation 3):

$$U_{tot} = \varepsilon\tau U_{obj} + (1-\varepsilon)\tau U_{refl} + (1-\tau)U_{atm}$$

Solve Equation 3 for U_{obj} (Equation 4):

$$U_{obj} = \frac{1}{\varepsilon\tau}U_{tot} - \frac{1-\varepsilon}{\varepsilon}U_{refl} - \frac{1-\tau}{\varepsilon\tau}U_{atm}$$

This is the general measurement formula used in all the Flir Systems thermographic equipment. The voltages of the formula are:

Table 27.1 Voltages

U_{obj}	Calculated camera output voltage for a blackbody of temperature T_{obj} i.e. a voltage that can be directly converted into true requested object temperature.
U_{tot}	Measured camera output voltage for the actual case.
U_{refl}	Theoretical camera output voltage for a blackbody of temperature T_{refl} according to the calibration.
U_{atm}	Theoretical camera output voltage for a blackbody of temperature T_{atm} according to the calibration.

The operator has to supply a number of parameter values for the calculation:

- the object emittance ε,
- the relative humidity,
- T_{atm}
- object distance (D_{obj})
- the (effective) temperature of the object surroundings, or the reflected ambient temperature T_{refl}, and
- the temperature of the atmosphere T_{atm}

This task could sometimes be a heavy burden for the operator since there are normally no easy ways to find accurate values of emittance and atmospheric transmittance for the actual case. The two temperatures are normally less of a problem provided the surroundings do not contain large and intense radiation sources.

A natural question in this connection is: How important is it to know the right values of these parameters? It could though be of interest to get a feeling for this problem already here by looking into some different measurement cases and compare the relative

magnitudes of the three radiation terms. This will give indications about when it is important to use correct values of which parameters.

The figures below illustrates the relative magnitudes of the three radiation contributions for three different object temperatures, two emittances, and two spectral ranges: SW and LW. Remaining parameters have the following fixed values:

- $\tau = 0.88$
- $T_{refl} = +20°C\ (+68°F)$
- $T_{atm} = +20°C\ (+68°F)$

It is obvious that measurement of low object temperatures are more critical than measuring high temperatures since the 'disturbing' radiation sources are relatively much stronger in the first case. Should also the object emittance be low, the situation would be still more difficult.

We have finally to answer a question about the importance of being allowed to use the calibration curve above the highest calibration point, what we call extrapolation. Imagine that we in a certain case measure $U_{tot} = 4.5$ volts. The highest calibration point for the camera was in the order of 4.1 volts, a value unknown to the operator. Thus, even if the object happened to be a blackbody, i.e. $U_{obj} = U_{tot}$, we are actually performing extrapolation of the calibration curve when converting 4.5 volts into temperature.

Let us now assume that the object is not black, it has an emittance of 0.75, and the transmittance is 0.92. We also assume that the two second terms of Equation 4 amount to 0.5 volts together. Computation of U_{obj} by means of Equation 4 then results in $U_{obj} = 4.5 / 0.75 / 0.92 – 0.5 = 6.0$. This is a rather extreme extrapolation, particularly when considering that the video amplifier might limit the output to 5 volts! Note, though, that the application of the calibration curve is a theoretical procedure where no electronic or other limitations exist. We trust that if there had been no signal limitations in the camera, and if it had been calibrated far beyond 5 volts, the resulting curve would have been very much the same as our real curve extrapolated beyond 4.1 volts, provided the calibration algorithm is based on radiation physics, like the Flir Systems algorithm. Of course there must be a limit to such extrapolations.

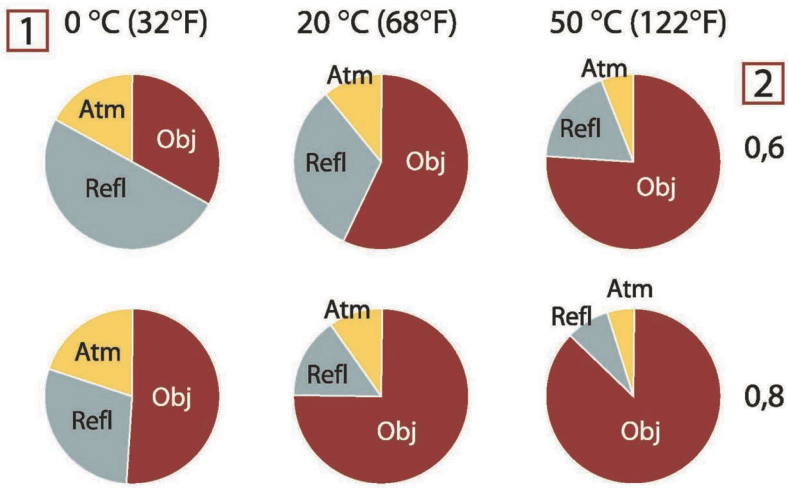

Figure 27.2 Relative magnitudes of radiation sources under varying measurement conditions (SW camera). 1: Object temperature; 2: Emittance; Obj: Object radiation; Refl: Reflected radiation; Atm: atmosphere radiation. Fixed parameters: $\tau = 0.88$; $T_{refl} = 20°C\ (+68°F)$; $T_{atm} = 20°C\ (+68°F)$.

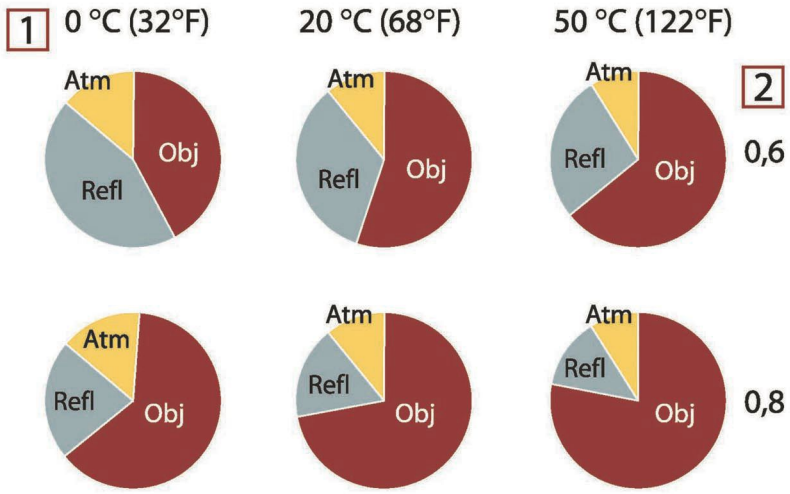

Figure 27.3 Relative magnitudes of radiation sources under varying measurement conditions (LW camera). 1: Object temperature; 2: Emittance; Obj: Object radiation; Refl: Reflected radiation; Atm: atmosphere radiation. Fixed parameters: $\tau = 0.88$; $T_{refl} = 20°C$ (+68°F); $T_{atm} = 20°C$ (+68°F).

28 Emissivity tables

This section presents a compilation of emissivity data from the infrared literature and measurements made by Flir Systems.

28.1 References

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11. Lohrengel & Todtenhaupt (1996)
12. ITC Technical publication 32.
13. ITC Technical publication 29.

Note
The emissivity values in the table below are recorded using a shortwave (SW) camera. The values should be regarded as recommendations only and used with caution.

28.2 Tables

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference

1	2	3	4	5	6
3M type 35	Vinyl electrical tape (several colors)	< 80	LW	Ca. 0.96	13
3M type 88	Black vinyl electrical tape	< 105	LW	Ca. 0.96	13
3M type 88	Black vinyl electrical tape	< 105	MW	< 0.96	13
3M type Super 33 +	Black vinyl electrical tape	< 80	LW	Ca. 0.96	13
Aluminum	anodized sheet	100	T	0.55	2
Aluminum	anodized, black, dull	70	SW	0.67	9
Aluminum	anodized, black, dull	70	LW	0.95	9
Aluminum	anodized, light gray, dull	70	SW	0.61	9
Aluminum	anodized, light gray, dull	70	LW	0.97	9

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference (continued)

1	2	3	4	5	6
Aluminum	as received, plate	100	T	0.09	4
Aluminum	as received, sheet	100	T	0.09	2
Aluminum	cast, blast cleaned	70	SW	0.47	9
Aluminum	cast, blast cleaned	70	LW	0.46	9
Aluminum	dipped in HNO_3, plate	100	T	0.05	4
Aluminum	foil	27	10 µm	0.04	3
Aluminum	foil	27	3 µm	0.09	3
Aluminum	oxidized, strongly	50–500	T	0.2–0.3	1
Aluminum	polished	50–100	T	0.04–0.06	1
Aluminum	polished plate	100	T	0.05	4
Aluminum	polished, sheet	100	T	0.05	2
Aluminum	rough surface	20–50	T	0.06–0.07	1
Aluminum	roughened	27	10 µm	0.18	3
Aluminum	roughened	27	3 µm	0.28	3
Aluminum	sheet, 4 samples differently scratched	70	SW	0.05–0.08	9
Aluminum	sheet, 4 samples differently scratched	70	LW	0.03–0.06	9
Aluminum	vacuum deposited	20	T	0.04	2
Aluminum	weathered, heavily	17	SW	0.83–0.94	5
Aluminum bronze		20	T	0.60	1
Aluminum hydroxide	powder		T	0.28	1
Aluminum oxide	activated, powder		T	0.46	1
Aluminum oxide	pure, powder (alumina)		T	0.16	1
Asbestos	board	20	T	0.96	1
Asbestos	fabric		T	0.78	1
Asbestos	floor tile	35	SW	0.94	7
Asbestos	paper	40–400	T	0.93–0.95	1
Asbestos	powder		T	0.40–0.60	1
Asbestos	slate	20	T	0.96	1
Asphalt paving		4	LLW	0.967	8
Brass	dull, tarnished	20–350	T	0.22	1
Brass	oxidized	100	T	0.61	2
Brass	oxidized	70	SW	0.04–0.09	9
Brass	oxidized	70	LW	0.03–0.07	9
Brass	oxidized at 600°C	200–600	T	0.59–0.61	1
Brass	polished	200	T	0.03	1

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference (continued)

1	2	3	4	5	6
Brass	polished, highly	100	T	0.03	2
Brass	rubbed with 80-grit emery	20	T	0.20	2
Brass	sheet, rolled	20	T	0.06	1
Brass	sheet, worked with emery	20	T	0.2	1
Brick	alumina	17	SW	0.68	5
Brick	common	17	SW	0.86–0.81	5
Brick	Dinas silica, glazed, rough	1100	T	0.85	1
Brick	Dinas silica, refractory	1000	T	0.66	1
Brick	Dinas silica, un-glazed, rough	1000	T	0.80	1
Brick	firebrick	17	SW	0.68	5
Brick	fireclay	1000	T	0.75	1
Brick	fireclay	1200	T	0.59	1
Brick	fireclay	20	T	0.85	1
Brick	masonry	35	SW	0.94	7
Brick	masonry, plastered	20	T	0.94	1
Brick	red, common	20	T	0.93	2
Brick	red, rough	20	T	0.88–0.93	1
Brick	refractory, corundum	1000	T	0.46	1
Brick	refractory, magnesite	1000–1300	T	0.38	1
Brick	refractory, strongly radiating	500–1000	T	0.8–0.9	1
Brick	refractory, weakly radiating	500–1000	T	0.65–0.75	1
Brick	silica, 95% SiO_2	1230	T	0.66	1
Brick	sillimanite, 33% SiO_2, 64% Al_2O_3	1500	T	0.29	1
Brick	waterproof	17	SW	0.87	5
Bronze	phosphor bronze	70	SW	0.08	9
Bronze	phosphor bronze	70	LW	0.06	9
Bronze	polished	50	T	0.1	1
Bronze	porous, rough	50–150	T	0.55	1
Bronze	powder		T	0.76–0.80	1
Carbon	candle soot	20	T	0.95	2
Carbon	charcoal powder		T	0.96	1
Carbon	graphite powder		T	0.97	1
Carbon	graphite, filed surface	20	T	0.98	2
Carbon	lampblack	20–400	T	0.95–0.97	1
Chipboard	untreated	20	SW	0.90	6

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference (continued)

1	2	3	4	5	6
Chromium	polished	50	T	0.10	1
Chromium	polished	500–1000	T	0.28–0.38	1
Clay	fired	70	T	0.91	1
Cloth	black	20	T	0.98	1
Concrete		20	T	0.92	2
Concrete	dry	36	SW	0.95	7
Concrete	rough	17	SW	0.97	5
Concrete	walkway	5	LLW	0.974	8
Copper	commercial, burnished	20	T	0.07	1
Copper	electrolytic, carefully polished	80	T	0.018	1
Copper	electrolytic, polished	–34	T	0.006	4
Copper	molten	1100–1300	T	0.13–0.15	1
Copper	oxidized	50	T	0.6–0.7	1
Copper	oxidized to blackness		T	0.88	1
Copper	oxidized, black	27	T	0.78	4
Copper	oxidized, heavily	20	T	0.78	2
Copper	polished	50–100	T	0.02	1
Copper	polished	100	T	0.03	2
Copper	polished, commercial	27	T	0.03	4
Copper	polished, mechanical	22	T	0.015	4
Copper	pure, carefully prepared surface	22	T	0.008	4
Copper	scraped	27	T	0.07	4
Copper dioxide	powder		T	0.84	1
Copper oxide	red, powder		T	0.70	1
Ebonite			T	0.89	1
Emery	coarse	80	T	0.85	1
Enamel		20	T	0.9	1
Enamel	lacquer	20	T	0.85–0.95	1
Fiber board	hard, untreated	20	SW	0.85	6
Fiber board	masonite	70	SW	0.75	9
Fiber board	masonite	70	LW	0.88	9
Fiber board	particle board	70	SW	0.77	9
Fiber board	particle board	70	LW	0.89	9
Fiber board	porous, untreated	20	SW	0.85	6
Gold	polished	130	T	0.018	1
Gold	polished, carefully	200–600	T	0.02–0.03	1
Gold	polished, highly	100	T	0.02	2
Granite	polished	20	LLW	0.849	8

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference (continued)

1	2	3	4	5	6
Granite	rough	21	LLW	0.879	8
Granite	rough, 4 different samples	70	SW	0.95–0.97	9
Granite	rough, 4 different samples	70	LW	0.77–0.87	9
Gypsum		20	T	0.8–0.9	1
Ice: See Water					
Iron and steel	cold rolled	70	SW	0.20	9
Iron and steel	cold rolled	70	LW	0.09	9
Iron and steel	covered with red rust	20	T	0.61–0.85	1
Iron and steel	electrolytic	100	T	0.05	4
Iron and steel	electrolytic	22	T	0.05	4
Iron and steel	electrolytic	260	T	0.07	4
Iron and steel	electrolytic, carefully polished	175–225	T	0.05–0.06	1
Iron and steel	freshly worked with emery	20	T	0.24	1
Iron and steel	ground sheet	950–1100	T	0.55–0.61	1
Iron and steel	heavily rusted sheet	20	T	0.69	2
Iron and steel	hot rolled	130	T	0.60	1
Iron and steel	hot rolled	20	T	0.77	1
Iron and steel	oxidized	100	T	0.74	4
Iron and steel	oxidized	100	T	0.74	1
Iron and steel	oxidized	1227	T	0.89	4
Iron and steel	oxidized	125–525	T	0.78–0.82	1
Iron and steel	oxidized	200	T	0.79	2
Iron and steel	oxidized	200–600	T	0.80	1
Iron and steel	oxidized strongly	50	T	0.88	1
Iron and steel	oxidized strongly	500	T	0.98	1
Iron and steel	polished	100	T	0.07	2
Iron and steel	polished	400–1000	T	0.14–0.38	1
Iron and steel	polished sheet	750–1050	T	0.52–0.56	1
Iron and steel	rolled sheet	50	T	0.56	1
Iron and steel	rolled, freshly	20	T	0.24	1
Iron and steel	rough, plane surface	50	T	0.95–0.98	1
Iron and steel	rusted red, sheet	22	T	0.69	4
Iron and steel	rusted, heavily	17	SW	0.96	5
Iron and steel	rusty, red	20	T	0.69	1
Iron and steel	shiny oxide layer, sheet,	20	T	0.82	1
Iron and steel	shiny, etched	150	T	0.16	1
Iron and steel	wrought, carefully polished	40–250	T	0.28	1

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference (continued)

1	2	3	4	5	6
Iron galvanized	heavily oxidized	70	SW	0.64	9
Iron galvanized	heavily oxidized	70	LW	0.85	9
Iron galvanized	sheet	92	T	0.07	4
Iron galvanized	sheet, burnished	30	T	0.23	1
Iron galvanized	sheet, oxidized	20	T	0.28	1
Iron tinned	sheet	24	T	0.064	4
Iron, cast	casting	50	T	0.81	1
Iron, cast	ingots	1000	T	0.95	1
Iron, cast	liquid	1300	T	0.28	1
Iron, cast	machined	800–1000	T	0.60–0.70	1
Iron, cast	oxidized	100	T	0.64	2
Iron, cast	oxidized	260	T	0.66	4
Iron, cast	oxidized	38	T	0.63	4
Iron, cast	oxidized	538	T	0.76	4
Iron, cast	oxidized at 600°C	200–600	T	0.64–0.78	1
Iron, cast	polished	200	T	0.21	1
Iron, cast	polished	38	T	0.21	4
Iron, cast	polished	40	T	0.21	2
Iron, cast	unworked	900–1100	T	0.87–0.95	1
Krylon Ultra-flat black 1602	Flat black	Room temperature up to 175	LW	Ca. 0.96	12
Krylon Ultra-flat black 1602	Flat black	Room temperature up to 175	MW	Ca. 0.97	12
Lacquer	3 colors sprayed on Aluminum	70	SW	0.50–0.53	9
Lacquer	3 colors sprayed on Aluminum	70	LW	0.92–0.94	9
Lacquer	Aluminum on rough surface	20	T	0.4	1
Lacquer	bakelite	80	T	0.83	1
Lacquer	black, dull	40–100	T	0.96–0.98	1
Lacquer	black, matte	100	T	0.97	2
Lacquer	black, shiny, sprayed on iron	20	T	0.87	1
Lacquer	heat–resistant	100	T	0.92	1
Lacquer	white	100	T	0.92	2
Lacquer	white	40–100	T	0.8–0.95	1
Lead	oxidized at 200°C	200	T	0.63	1
Lead	oxidized, gray	20	T	0.28	1
Lead	oxidized, gray	22	T	0.28	4
Lead	shiny	250	T	0.08	1
Lead	unoxidized, polished	100	T	0.05	4
Lead red		100	T	0.93	4
Lead red, powder		100	T	0.93	1

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference (continued)

1	2	3	4	5	6
Leather	tanned		T	0.75–0.80	1
Lime			T	0.3–0.4	1
Magnesium		22	T	0.07	4
Magnesium		260	T	0.13	4
Magnesium		538	T	0.18	4
Magnesium	polished	20	T	0.07	2
Magnesium powder			T	0.86	1
Molybdenum		1500–2200	T	0.19–0.26	1
Molybdenum		600–1000	T	0.08–0.13	1
Molybdenum	filament	700–2500	T	0.1–0.3	1
Mortar		17	SW	0.87	5
Mortar	dry	36	SW	0.94	7
Nextel Velvet 811-21 Black	Flat black	–60–150	LW	> 0.97	10 and 11
Nichrome	rolled	700	T	0.25	1
Nichrome	sandblasted	700	T	0.70	1
Nichrome	wire, clean	50	T	0.65	1
Nichrome	wire, clean	500–1000	T	0.71–0.79	1
Nichrome	wire, oxidized	50–500	T	0.95–0.98	1
Nickel	bright matte	122	T	0.041	4
Nickel	commercially pure, polished	100	T	0.045	1
Nickel	commercially pure, polished	200–400	T	0.07–0.09	1
Nickel	electrolytic	22	T	0.04	4
Nickel	electrolytic	260	T	0.07	4
Nickel	electrolytic	38	T	0.06	4
Nickel	electrolytic	538	T	0.10	4
Nickel	electroplated on iron, polished	22	T	0.045	4
Nickel	electroplated on iron, unpolished	20	T	0.11–0.40	1
Nickel	electroplated on iron, unpolished	22	T	0.11	4
Nickel	electroplated, polished	20	T	0.05	2
Nickel	oxidized	1227	T	0.85	4
Nickel	oxidized	200	T	0.37	2
Nickel	oxidized	227	T	0.37	4
Nickel	oxidized at 600°C	200–600	T	0.37–0.48	1
Nickel	polished	122	T	0.045	4
Nickel	wire	200–1000	T	0.1–0.2	1
Nickel oxide		1000–1250	T	0.75–0.86	1
Nickel oxide		500–650	T	0.52–0.59	1
Oil, lubricating	0.025 mm film	20	T	0.27	2

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference (continued)

1	2	3	4	5	6
Oil, lubricating	0.050 mm film	20	T	0.46	2
Oil, lubricating	0.125 mm film	20	T	0.72	2
Oil, lubricating	film on Ni base: Ni base only	20	T	0.05	2
Oil, lubricating	thick coating	20	T	0.82	2
Paint	8 different colors and qualities	70	SW	0.88–0.96	9
Paint	8 different colors and qualities	70	LW	0.92–0.94	9
Paint	Aluminum, various ages	50–100	T	0.27–0.67	1
Paint	cadmium yellow		T	0.28–0.33	1
Paint	chrome green		T	0.65–0.70	1
Paint	cobalt blue		T	0.7–0.8	1
Paint	oil	17	SW	0.87	5
Paint	oil based, average of 16 colors	100	T	0.94	2
Paint	oil, black flat	20	SW	0.94	6
Paint	oil, black gloss	20	SW	0.92	6
Paint	oil, gray flat	20	SW	0.97	6
Paint	oil, gray gloss	20	SW	0.96	6
Paint	oil, various colors	100	T	0.92–0.96	1
Paint	plastic, black	20	SW	0.95	6
Paint	plastic, white	20	SW	0.84	6
Paper	4 different colors	70	SW	0.68–0.74	9
Paper	4 different colors	70	LW	0.92–0.94	9
Paper	black		T	0.90	1
Paper	black, dull		T	0.94	1
Paper	black, dull	70	SW	0.86	9
Paper	black, dull	70	LW	0.89	9
Paper	blue, dark		T	0.84	1
Paper	coated with black lacquer		T	0.93	1
Paper	green		T	0.85	1
Paper	red		T	0.76	1
Paper	white	20	T	0.7–0.9	1
Paper	white bond	20	T	0.93	2
Paper	white, 3 different glosses	70	SW	0.76–0.78	9
Paper	white, 3 different glosses	70	LW	0.88–0.90	9
Paper	yellow		T	0.72	1
Plaster		17	SW	0.86	5
Plaster	plasterboard, untreated	20	SW	0.90	6

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference (continued)

1	2	3	4	5	6
Plaster	rough coat	20	T	0.91	2
Plastic	glass fibre laminate (printed circ. board)	70	SW	0.94	9
Plastic	glass fibre laminate (printed circ. board)	70	LW	0.91	9
Plastic	polyurethane isolation board	70	LW	0.55	9
Plastic	polyurethane isolation board	70	SW	0.29	9
Plastic	PVC, plastic floor, dull, structured	70	SW	0.94	9
Plastic	PVC, plastic floor, dull, structured	70	LW	0.93	9
Platinum		100	T	0.05	4
Platinum		1000–1500	T	0.14–0.18	1
Platinum		1094	T	0.18	4
Platinum		17	T	0.016	4
Platinum		22	T	0.03	4
Platinum		260	T	0.06	4
Platinum		538	T	0.10	4
Platinum	pure, polished	200–600	T	0.05–0.10	1
Platinum	ribbon	900–1100	T	0.12–0.17	1
Platinum	wire	1400	T	0.18	1
Platinum	wire	500–1000	T	0.10–0.16	1
Platinum	wire	50–200	T	0.06–0.07	1
Porcelain	glazed	20	T	0.92	1
Porcelain	white, shiny		T	0.70–0.75	1
Rubber	hard	20	T	0.95	1
Rubber	soft, gray, rough	20	T	0.95	1
Sand			T	0.60	1
Sand		20	T	0.90	2
Sandstone	polished	19	LLW	0.909	8
Sandstone	rough	19	LLW	0.935	8
Silver	polished	100	T	0.03	2
Silver	pure, polished	200–600	T	0.02–0.03	1
Skin	human	32	T	0.98	2
Slag	boiler	0–100	T	0.97–0.93	1
Slag	boiler	1400–1800	T	0.69–0.67	1
Slag	boiler	200–500	T	0.89–0.78	1
Slag	boiler	600–1200	T	0.76–0.70	1
Snow: See Water					
Soil	dry	20	T	0.92	2
Soil	saturated with water	20	T	0.95	2

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference (continued)

1	2	3	4	5	6
Stainless steel	alloy, 8% Ni, 18% Cr	500	T	0.35	1
Stainless steel	rolled	700	T	0.45	1
Stainless steel	sandblasted	700	T	0.70	1
Stainless steel	sheet, polished	70	SW	0.18	9
Stainless steel	sheet, polished	70	LW	0.14	9
Stainless steel	sheet, untreated, somewhat scratched	70	SW	0.30	9
Stainless steel	sheet, untreated, somewhat scratched	70	LW	0.28	9
Stainless steel	type 18-8, buffed	20	T	0.16	2
Stainless steel	type 18-8, oxidized at 800°C	60	T	0.85	2
Stucco	rough, lime	10–90	T	0.91	1
Styrofoam	insulation	37	SW	0.60	7
Tar			T	0.79–0.84	1
Tar	paper	20	T	0.91–0.93	1
Tile	glazed	17	SW	0.94	5
Tin	burnished	20–50	T	0.04–0.06	1
Tin	tin–plated sheet iron	100	T	0.07	2
Titanium	oxidized at 540°C	1000	T	0.60	1
Titanium	oxidized at 540°C	200	T	0.40	1
Titanium	oxidized at 540°C	500	T	0.50	1
Titanium	polished	1000	T	0.36	1
Titanium	polished	200	T	0.15	1
Titanium	polished	500	T	0.20	1
Tungsten		1500–2200	T	0.24–0.31	1
Tungsten		200	T	0.05	1
Tungsten		600–1000	T	0.1–0.16	1
Tungsten	filament	3300	T	0.39	1
Varnish	flat	20	SW	0.93	6
Varnish	on oak parquet floor	70	SW	0.90	9
Varnish	on oak parquet floor	70	LW	0.90–0.93	9
Wallpaper	slight pattern, light gray	20	SW	0.85	6
Wallpaper	slight pattern, red	20	SW	0.90	6
Water	distilled	20	T	0.96	2
Water	frost crystals	–10	T	0.98	2
Water	ice, covered with heavy frost	0	T	0.98	1
Water	ice, smooth	0	T	0.97	1
Water	ice, smooth	–10	T	0.96	2

Table 28.1 T: Total spectrum; SW: 2–5 µm; LW: 8–14 µm, LLW: 6.5–20 µm; 1: Material; 2: Specification; 3:Temperature in °C; 4: Spectrum; 5: Emissivity: 6:Reference (continued)

1	2	3	4	5	6
Water	layer >0.1 mm thick	0–100	T	0.95–0.98	1
Water	snow		T	0.8	1
Water	snow	–10	T	0.85	2
Wood		17	SW	0.98	5
Wood		19	LLW	0.962	8
Wood	ground		T	0.5–0.7	1
Wood	pine, 4 different samples	70	SW	0.67–0.75	9
Wood	pine, 4 different samples	70	LW	0.81–0.89	9
Wood	planed	20	T	0.8–0.9	1
Wood	planed oak	20	T	0.90	2
Wood	planed oak	70	SW	0.77	9
Wood	planed oak	70	LW	0.88	9
Wood	plywood, smooth, dry	36	SW	0.82	7
Wood	plywood, untreated	20	SW	0.83	6
Wood	white, damp	20	T	0.7–0.8	1
Zinc	oxidized at 400°C	400	T	0.11	1
Zinc	oxidized surface	1000–1200	T	0.50–0.60	1
Zinc	polished	200–300	T	0.04–0.05	1
Zinc	sheet	50	T	0.20	1

A note on the technical production of this publication

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